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RESPIRATORY CARE

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47th International Respiratory Congress
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December 1-4, 2001, San Antonio, Texas

EDITORIALS

Unintended Consequences of Artificial Airways

CASE REPORTS

Tracheal-Innominate Artery Fistula Caused by the Endotracheal Tube Tip

Airway Pressure Release Ventilation with Short Release Time in a Child with ARDS

SPECIAL ARTICLES

Implementation of a Low Tidal Volume Ventilation Protocol for Patients with Acute Lung Injury or ARDS

How to Buy a Ventilator

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DuoNeb is indicated for the treatment of bronchospasm associated with COPD in patients requiring more than one bronchodilator. In a 12-week clinical study, the most common adverse reactions reported with DuoNeb Inhalation Solution were chest pain, pharyngitis, diarrhea, bronchitis, nausea and leg cramps.

Albuterol sulfate can have a significant cardiovascular effect, significant hypokalemia and the potential life-threatening paradoxical bronchospasm. Caution is advised in patients with convulsive disorders, hyperthyroidism, diabetes mellitus, narrow-angle glaucoma, prostatic hypertrophy or bladder-neck obstruction. Co-administration of DuoNeb Inhalation Solution and other sympathomimetic agents may increase the risk of adverse cardiovascular effects.

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BRIEF SUMMARY OF PRESCRIBING INFORMATION

INDICATIONS AND USAGE

DuoNeb is indicated for the treatment of bronchospasm associated with COPD in patients requiring more than one bronchodilator.

CONTRAINDICATIONS

DuoNeb is contraindicated in patients with a history of hypersensitivity to any of its components, or to atropine and its derivatives.

WARNINGS

Paradoxical Bronchospasm: In the clinical study of DuoNeb, paradoxical bronchospasm was not observed. However, paradoxical bronchospasm has been observed with both inhaled ipratropium bromide and albuterol products and can be life-threatening. If this occurs, DuoNeb should be discontinued immediately and alternative therapy instituted.

Do Not Exceed Recommended Dose: Fatalities have been reported in association with excessive use of inhaled products containing sympathomimetic amines and with the home use of nebulizers.

Cardiovascular Effect. DuoNeb, like other beta adrenergic agonists, can produce a clinically significant cardiovascular effect in some patients as measured by pulse rate, blood pressure, and/or symptoms. Although such effects are uncommon for DuoNeb at recommended doses, if they occur, the drug may need to be discontinued. In addition, beta agonists have been reported to produce ECG changes, such as flattening of the T-wave, prolongation of the QTc interval, and ST segment depression. The clinical significance of these findings is unknown. Therefore, DuoNeb, like other sympathomimetic amines, should be used with caution in patients with cardiovascular disorders, especially coronary insufficiency, cardiac arrhythmias, and hypertension.

Immediate Hypersensitivity Reactions: Immediate hypersensitivity reactions to albuterol and/or ipratropium bromide may occur after the administration of DuoNeb as demonstrated by rare cases of urticaria, angioedema, rash, pruritus, oropharyngeal edema, bronchospasm, and anaphylaxis.

PRECAUTIONS

General

1. Effects Seen with Sympathomimetic Drugs: As with all products containing sympathomimetic amines, DuoNeb should be used with caution in patients with cardiovascular disorders, especially coronary insufficiency, cardiac arrhythmias, and hypertension, in patients with convulsive disorders, hyperthyroidism, or diabetes mellitus; and in patients who are unusually responsive to sympathomimetic amines. Large doses of intravenous albuterol have been reported to aggravate pre-existing diabetes mellitus and ketoacidosis. Additionally, β-agonists may cause a decrease in serum potassium in some patients, possibly through intracellular shunting. The decrease is usually transient, not requiring supplementation.

2. Effects Seen with Anticholinergic Drugs: Due to the presence of ipratropium bromide in DuoNeb, it should be used with caution in patients with narrow-angle glaucoma, prostatic hypertrophy, or bladder-neck obstruction.

3. Use in Hepatic or Renal Diseases. DuoNeb has not been studied in patients with hepatic or renal insufficiency. It should be used with caution in these patient populations.

Information for Patients

The action of DuoNeb should last up to 5 hours. DuoNeb should not be used more frequently than recommended. Patients should be instructed not to increase the dose or frequency of DuoNeb without consulting their healthcare provider. If symptoms worsen, patients should be instructed to seek medical consultation.

Patients must avoid exposing their eyes to this product as temporary papillary dilation, blurred vision, eye pain, or precipitation or worsening of narrow-angle glaucoma may occur, and therefore proper nebulizer technique should be assured, particularly if a mask is used.

If a patient becomes pregnant or begins nursing while on DuoNeb, they should contact their healthcare provider about use of DuoNeb.

See the illustrated Patient's Instruction for Use in the product package insert.

Drug Interactions

Anticholinergic agents: Although ipratropium bromide is minimally absorbed into the systemic circulation, there is some potential for an additive interaction with concomitantly used anticholinergic medications. Caution is, therefore, advised in the co-administration of DuoNeb with other drugs having anticholinergic properties.

β-adrenergic agents: Caution is advised in the co-administration of DuoNeb and other sympathomimetic agents due to the increased risk of adverse cardiovascular effects.

β-receptor blocking agents. These agents and albuterol sulfate inhibit the effect of each other. β-receptor blocking agents should be used with caution in patients with hyperreactive airways, and if used, relatively selective β_1 selective agents are recommended.

Diuretics: The electrocardiogram (ECG) changes and/or hypokalemia that may result from the administration of non-potassium sparing diuretics (such as loop or thiazide diuretics) can be acutely worsened by β-agonists, especially when the recommended dose of the β-agonist is exceeded. Although the clinical significance of these effects is not known, caution is advised in the co-administration of β-agonist-containing drugs, such as DuoNeb, with non-potassium sparing diuretics.

Monoamine oxidase inhibitors or tricyclic antidepressants: DuoNeb should be administered with extreme caution to patients being treated with monoamine oxidase inhibitors or tricyclic antidepressants, or within 2 weeks of discontinuation of such agents because the action of albuterol sulfate on the cardiovascular system may be potentiated.

Carcinogenesis, Mutagenesis, Impairment of Fertility

Albuterol Sulfate: In a 2-year study in Sprague-Dawley rats, albuterol sulfate caused a significant dose-related increase in the incidence of benign leiomyomas of the mesovarium at and above dietary doses of 2 mg/kg (approximately equal to the maximum recommended daily inhalation dose for adults on a mg/m² basis). In another study, this effect was blocked by the coadministration of propranolol, a non-selective beta-adrenergic antagonist.

In an 18-month study in CD-1 mice, albuterol sulfate showed no evidence of tumorigenicity at dietary doses up to 500 mg/kg (approximately 140 times the maximum recommended daily inhalation dose for adults on a mg/m² basis). In a 22-month study in Golden hamsters, albuterol sulfate showed no evidence of tumorigenicity at dietary doses up to 50 mg/kg (approximately 20 times the maximum recommended daily inhalation dose for adults on a mg/m² basis).

Albuterol sulfate was not mutagenic in the Ames test or a mutation test in yeast. Albuterol sulfate was not clastogenic in a human peripheral lymphocyte assay or in an AH1 strain mouse micronucleous assay.

Reproduction studies in rats demonstrated no evidence of impaired fertility at oral doses of albuterol sulfate up to 50 mg/kg (approximately 25 times the maximum recommended daily inhalation dose for adults on a mg/m² basis).

Ipratropium bromide: In 2-year studies in Sprague-Dawley rats and CD-1 mice, ipratropium bromide showed no evidence of tumorigenicity at oral doses up to 6 mg/kg (approximately 15 times and 8 times the maximum recommended daily inhalation dose for adults in rats and mice respectively, on a mg/m² basis).

Ipratropium bromide was not mutagenic in the Ames test and mouse dominant lethal test. Ipratropium bromide was not clastogenic in a mouse micronucleous assay.

A reproduction study in rats demonstrated decreased conception and increased resorptions when ipratropium bromide was administered orally at a dose of 90 mg/kg (approximately 240 times the maximum recommended daily inhalation dose for adults on a mg/m² basis). These effects were not seen with a dose of 50 mg/kg (approximately 140 times the maximum recommended daily inhalation dose for adults on a mg/m² basis).

Pregnancy

TERATOGENIC EFFECTS Pregnancy Category C

Albuterol sulfate. *Pregnancy Category C.* Albuterol sulfate has been shown to be teratogenic in mice. A study in CD-1 mice given albuterol sulfate subcutaneously showed cleft palate formation in 5 of 111 (4.5%) fetuses at 0.25 mg/kg (less than the maximum recommended daily inhalation dose for adults on a mg/m² basis) and in 10 of 108 (9.3%) fetuses at 2.5 mg/kg (approximately equal to the maximum recommended daily inhalation dose for adults on a mg/m² basis). The drug did not induce cleft palate formation when administered subcutaneously at a dose of 0.025 mg/kg (less than the maximum recommended daily inhalation dose for adults on a mg/m² basis). Cleft palate formation also occurred in 22 of 72 (30.5%) fetuses from females treated subcutaneously with 2.5 mg/kg isoproterenol (positive control).

A reproduction study in Stride rabbits revealed cranioschisis in 7 of 19 (37%) fetuses when albuterol was administered orally at a dose of 50 mg/kg (approximately 55 times the maximum recommended daily inhalation dose for adults on a mg/m² basis).

A study in which pregnant rats were dosed with radiolabeled albuterol sulfate demonstrated that drug-related material is transferred from the maternal circulation to the fetus.

During worldwide marketing experience, various congenital anomalies, including cleft palate and limb defects, have been reported in the offspring of patients being treated with albuterol. Some of the mothers were taking multiple medications during their pregnancies. Because no consistent pattern of defects can be discerned, a relationship between albuterol use and congenital anomalies has not been established.

Ipratropium bromide. *Pregnancy Category B.* Reproduction studies in CD-1 mice, Sprague-Dawley rats and New Zealand rabbits demonstrated no evidence of teratogenicity at oral doses up to 10, 100, and 125 mg/kg, respectively (approximately 15, 270, and 680 times the maximum recommended daily inhalation dose for adults on a mg/m² basis). Reproduction studies in rats and rabbits demonstrated no evidence of teratogenicity at inhalation doses up to 1.5 and 1.8 mg/kg, respectively (approximately 4 and 10 times the maximum recommended daily inhalation dose for adults on a mg/m² basis). There are no adequate and well-controlled studies of the use of DuoNeb, albuterol sulfate, or ipratropium bromide in pregnant women. DuoNeb should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

Labor and Delivery

Oral albuterol sulfate has been shown to delay preterm labor in some reports. Because of the potential of albuterol to interfere with uterine contractility, use of DuoNeb during labor should be restricted to those patients in whom the benefits clearly outweigh the risks.

Nursing Mothers

It is not known whether the components of DuoNeb are excreted in human milk. Although lipid-insoluble quaternary bases pass into breast milk, it is unlikely that ipratropium bromide would reach the infant to an important extent, especially when taken as a nebulized solution. Because of the potential for tumorigenicity shown for albuterol sulfate in some animals, a decision should be made whether to discontinue nursing or discontinue DuoNeb, taking into account the importance of the drug to the mother.

Pediatric Use

The safety and effectiveness of DuoNeb in patients below 18 years of age have not been established.

Geriatric Use

Of the total number of subjects in clinical studies of DuoNeb, 62 percent were 65 and over, while 19 percent were 75 and over. No overall differences in safety or effectiveness were observed between these subjects and younger subjects, and other reported clinical experience has not identified differences in responses between the elderly and younger patients, but greater sensitivity of some older individuals cannot be ruled out.

ADVERSE REACTIONS

Adverse reaction information concerning DuoNeb was derived from the 12-week controlled clinical trial.

ADVERSE EVENTS OCCURRING IN ≥ 1% OF ≥ 1 TREATMENT GROUP(S) AND WHERE THE COMBINATION TREATMENT SHOWED THE HIGHEST PERCENTAGE

Body System COSTART Term	Albuterol n (%)	Ipratropium n (%)	DuoNeb n (%)
NUMBER OF PATIENTS	761	754	765
N (%) Patients with AE	327 (43.0)	329 (43.6)	367 (48.0)
BODY AS A WHOLE			
Pain	8 (1.1)	4 (0.5)	10 (1.3)
Pain chest	11 (1.4)	14 (1.9)	20 (2.6)
DIGESTIVE			
Diarrhea	5 (0.7)	9 (1.2)	14 (1.8)
Dyspepsia	7 (0.9)	8 (1.1)	10 (1.3)
Nausea	7 (0.9)	6 (0.8)	11 (1.4)
MUSCULO-SKELETAL			
Cramps leg	8 (1.1)	6 (0.8)	11 (1.4)
RESPIRATORY			
Bronchitis	11 (1.4)	13 (1.7)	13 (1.7)
Lung Disease	36 (4.7)	34 (4.5)	49 (6.4)
Pharyngitis	27 (3.5)	27 (3.6)	34 (4.4)
Pneumonia	7 (0.9)	8 (1.1)	10 (1.3)
UROGENITAL			
Infection urinary tract	3 (0.4)	9 (1.2)	12 (1.6)

Additional adverse reactions reported in more than 1% of patients treated with DuoNeb included constipation and voice alterations.

In the clinical trial, there was a 0.3% incidence of possible allergic-type reactions, including skin rash, pruritus, and urticaria.

Additional information derived from the published literature on the use of albuterol sulfate and ipratropium bromide singly or in combination includes precipitation or worsening of narrow-angle glaucoma, acute eye pain, blurred vision, paradoxical bronchospasm, wheezing, exacerbation of COPD symptoms, drowsiness, aching, flushing, upper respiratory tract infection, palpitations, taste perversion, elevated heart rate, sinusitis, back pain and sore throat.

DOSAGE AND ADMINISTRATION

The recommended dose of DuoNeb is one 3 mL vial administered 4 times per day via nebulization with up to 2 additional 3 mL doses allowed per day, if needed. Safety and efficacy of additional doses or increased frequency of administration of DuoNeb beyond these guidelines has not been studied and the safety and efficacy of extra doses of albuterol sulfate or ipratropium bromide in addition to the recommended doses of DuoNeb have not been studied.

The use of DuoNeb can be continued as medically indicated to control recurring bouts of bronchospasm. If a previously effective regimen fails to provide the usual relief, medical advice should be sought immediately, as this is often a sign of worsening COPD, which would require reassessment of therapy.

A Pari-LC-Plus™ nebulizer (with face mask or mouthpiece) connected to a PRONEB™ compressor was used to deliver DuoNeb to each patient in one U.S. clinical study. The safety and efficacy of DuoNeb delivered by other nebulizers and compressors have not been established.

DuoNeb should be administered via jet nebulizer connected to an air compressor with an adequate air flow, equipped with a mouthpiece or suitable face mask.

HOW SUPPLIED

DuoNeb is supplied as a 3-mL sterile solution for nebulization in sterile low-density polyethylene unit-dose vials. Cards of five vials are placed into a foil pouch. Supplied in cartons as listed below:

NDC 49502-672-30	30 vials per carton
NDC 49502-672-60	60 vials per carton

Store between 2°C and 25°C (36°F and 77°F). Protect from light.

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03-485-21(BRS)

May 2001

1. Gross N, Tashkin D, Miller R, et al. Inhalation by nebulization of albuterol-ipratropium combination (Dey combination) is superior to either agent alone in the treatment of chronic obstructive pulmonary disease. *Respiration.* 1998;65:354-362.

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St. Joseph Trinity Hospital
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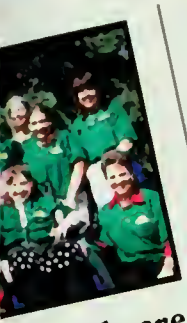
Gary McMillan
Director of Pulmonary Services
Sparrow Hospital, Lansing MI



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We encourage you to provide us with information and contacts for other qualified vent camps. And will continue to recognize clinicians who support these worthwhile endeavors. There is nothing more precious than to see these individuals enjoying life through fun activities with their peers.

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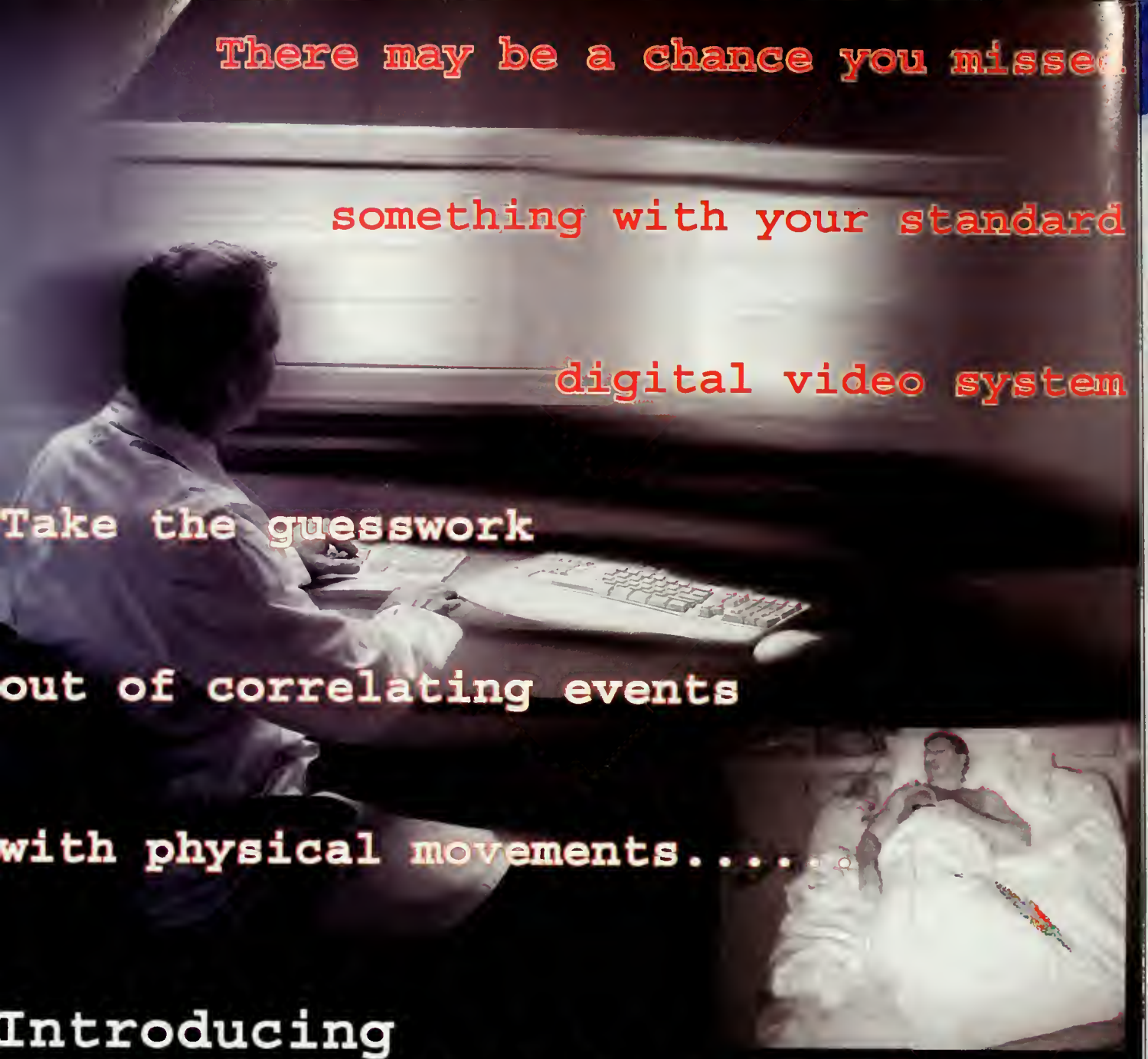
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What Is Apoptosis, and Why Is It Important?—Renehan AG, Booth C, Potten CS. BMJ 2001;322(7301):1536–1538.

Autoadjusting Continuous Positive Airway Pressure: What Can We Expect? (editorial)—Levy P, Pepin JL. Am J Respir Crit Care Med 2001;163(6):1295–1296.

Enter the Stranger: The Story of Xenon (historical article)—Bates DV. Am J Respir Crit Care Med 2001;163(6):1302–1303.

A Thousand Years of Pulmonary Medicine: Good News and Bad—Murray JF. Eur Respir J 2001;17(3):558–565.

Long Term Sequelae of Bronchopulmonary Dysplasia (Chronic Lung Disease of Infancy)—Eber E, Zach MS. Thorax 2001;56(4):317–323.

Ventilating the Acutely Injured Lung (historical article)—Fairley HB. Am J Respir Crit Care Med 2001;163(5):1049–1050.

Patient-Ventilator Interaction—Tobin MJ, Jubran A, Laghi F. Am J Respir Crit Care Med 2001;163(5):1059–1063.

Use of an Implantable Pleural Catheter for Trapped Lung Syndrome in Patients with Malignant Pleural Effusion—Pien GW, Gant MJ, Washam CL, Sterman DH. Chest 2001;119(6):1641–1646.

Study objectives: We describe a series of patients with symptomatic, refractory malignant pleural effusion (MPE) and underlying trapped lung syndrome who underwent placement of a small-bore, flexible indwelling pleural catheter for home drainage of recurrent MPE. DESIGN: The medical records of 11 consecutive patients who underwent pleural catheter placement for MPE with trapped lung syndrome were reviewed retrospectively. SETTING: Patients were evaluated and followed up in the Pulmonary Outpatient Practice at the Hospital of the University of Pennsylvania. PATIENTS: Nine men and two women with underlying malignancies including lung cancer, lymphoma, and mesothelioma underwent pleural catheter placement. INTERVENTIONS: Thirteen pleural catheters were placed in 11 patients, all under local anesthesia. Patients received detailed instructions for drainage and catheter care. They were reevaluated weekly for the first 2 weeks, and then as clinically indicated. Patients typically performed pleural drainage at home up to 1,000 mL two or three times weekly. Measurements and results: All patients reported symptomatic benefit, defined as improved dyspnea and exercise tolerance, except for one patient. In 10 patients, the pleural catheters remained in place until death, for 15 to 234 days. The mean length of placement was 115 days. One patient required revision after catheter occlusion. Other complications included catheter infection, localized skin breakdown, and possible cellulitis. CONCLUSION: We have described a series of patients with MPE and trapped lung syndrome for whom placement of a permanent pleural catheter provided a convenient, effective alternative to the procedures currently in use. Our patients reported good symptomatic relief following catheter placement with few major complications.

Salmeterol Plus Theophylline Combinatinn Therapy in the Treatment of COPD—ZuWallack RL, Mahler DA, Reilly D, Church N, Emmett A, Rickard K, Knobil K. Chest 2001;119(6):1661–1670.

BACKGROUND: Patients with COPD often require multiple therapies to improve lung function and decrease symptoms and exacerbations. Salmeterol and theophylline are indicated for the treatment of COPD, but the use of these agents in combination has not been extensively studied. OBJECTIVES: To compare the efficacy and safety of salmeterol plus theophylline vs either agent alone in COPD. METHODS: Randomized, double-blind, double-dummy, parallel-group trial in 943 patients with COPD. After an open-label theophylline titration period (serum levels, 10 to 20 microg/mL), patients were randomly assigned to receive salmeterol (42 microg bid) plus theophylline, salmeterol (42 microg bid), or theophylline for 12 weeks. Serial pulmonary function tests were completed on day 1 and treatment week 12. Patients kept diary cards and noted their peak flow rates, symptom scores, and albuterol use, and periodically completed quality-of-life and dyspnea questionnaires. RESULTS: All three groups significantly improved compared with baseline. Combination treatment with salmeterol plus theophylline provided significantly ($p \leq 0.045$) greater improvements in pulmonary function; significantly ($p \leq 0.048$) greater decreases in symptoms, dyspnea, and albuterol use; and significantly fewer COPD exacerbations ($p = 0.023$ vs theophylline). In general, treatment with salmeterol provided greater improvement in lung function and satisfaction with treatment compared with theophylline. Salmeterol treatment was also associated with significantly fewer drug-related adverse events ($p \leq 0.042$) than either treatment that included theophylline. The safety profile (adverse events, vital signs, and ECG findings) of the two treatments that included theophylline were similar. CONCLUSION: Patients with COPD may benefit from combi-

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nation treatment with salmeterol plus theophylline, without a resulting increase in adverse events or other adverse sequelae.

The Prevalence of Exercise-Induced Bronchospasm Among US Army Recruits and Its Effects on Physical Performance—Sonna LA, Angel KC, Sharp MA, Knapik JJ, Patton JF, Lilly CM. Chest 2001;119(6): 1676–1684.

Study objectives: To measure the prevalence of exercise-induced bronchospasm (EIB) and to determine its effect on the physical performance response to training in otherwise healthy young adults. DESIGN: Observational, retrospective study. SETTING: Fort Jackson, SC, May to July 1998. PARTICIPANTS: One hundred thirty-seven ethnically diverse US Army recruits undergoing an 8-week Army basic training course. Measurements and results: Subjects underwent exercise challenge testing at the end of basic training to evaluate for EIB (defined as a decrease in FEV_1 of $\geq$ 15%, 1 or 10 min after running to peak oxygen uptake on a treadmill). Those subjects who were unable to run to peak oxygen uptake, or who were unable to perform two baseline FEV_1 maneuvers the results of which were within 5% of each other, were excluded from analysis. We measured peak oxygen uptake on a treadmill and the scores achieved on the components of the US Army physical fitness test (APFT). Of 137 subjects, 121 (58 men and 63 women) met our inclusion criteria. Eight subjects (7%) had EIB. Subjects who experienced EIB and unaffected control subjects both showed statistically significant gains in performance on the APFT events during basic training. At the end of basic training, peak oxygen uptake levels and APFT event scores were not significantly different between subjects with EIB and unaffected control subjects. CONCLUSIONS: Seven percent of the US Army recruits who were tested had EIB, but this did not hinder their physical performance gains during basic training. EIB per se should not be an absolute reason to exclude individuals from employment in jobs with heavy physical demands.

Gender Bias in the Diagnosis of COPD—Chapman KR, Tashkin DP, Pye DJ. Chest 2001;119(6):1691–1695.

BACKGROUND: COPD is thought to be more prevalent among men than women, a finding usually attributed to higher smoking rates and more frequent occupational exposures of significance for men. However, smoking prevalence has increased among women and there is evidence that women may be more susceptible to the adverse pulmonary function effects of smoking than men. There may also be underdiagnosis and misdiagnosis of COPD in both sexes because objective measures of lung function are underused. OBJECTIVES: We undertook the present study to determine if there is gender bias in the diagnosis of COPD, such that women are less likely than men to receive a diagnosis of COPD. We also attempted to determine if underuse of lung function measurements was a factor in any bias detected. METHODS: We surveyed a random sample of 192 primary-care physicians (96 American and 96 Canadian; 154 men and 38 women) using a hypothetical case presentation and a structured interview. The case of cough and dyspnea in a smoker was presented in six versions differing only in the age and sex of the patient. After presentation of the history and physical findings, physicians were asked to state the most probable diagnosis and to choose the diagnostic studies needed. Physicians were then presented with spirometric findings of moderate or severe obstruction without significant bronchodilator response, and the questions repeated. Finally, the negative outcome of an oral steroid trial was described. RESULTS: Initially, COPD was given as the most probable diagnosis significantly more often for men than women (58% vs 42%; $p < 0.05$). The likelihood of a COPD diagnosis increased significantly and initial differences between sexes decreased as objective information was provided. After spirometry, COPD diagnosis rates for men and women were 74% vs 66% (p = not significant); after the steroid trial 85% vs 79% (p = not significant). Only 22% of physicians would have requested spirometry after the initial presentation. CONCLUSIONS: In North America, primary-care physicians underdiagnose COPD, particularly in women. Spirometry reduces the risk of underdiagnosis and gender bias but is underused.

The Effectiveness of Outpatient Pulmonary Rehabilitation in Chronic Lung Disease: A Randomized Controlled Trial—Finnerty JP, Keeping I, Bullough I, Jones J. Chest 2001;119(6):1705–1710.

BACKGROUND: Patients with chronic pulmonary disease have been shown to benefit from pulmonary rehabilitation programs. Published work has often been from specialized teaching centers and has involved inpatient stay. We assessed an entirely outpatient-based program of pulmonary rehabilitation in patients with chronic lung disease, using the St. George's Respiratory Questionnaire (SGRQ) (which measures health-related quality of life) as the primary outcome measure. METHODS: We undertook a randomized, prospective, parallel-group controlled study of an outpatient rehabilitation program in 65 patients with COPD (44 men and 21 women; mean age, 69.5 years [SD, 9.2 years]; FEV_1, 41% predicted [SD, 18.5%]). The active group (n = 36) took part in a 6-week program of education (2 h weekly) and exercise (1 h weekly). The control group (n = 29) were reviewed routinely as medical outpatients. The SGRQ was administered under supervision by a blinded observer at study entry, 12 weeks, and 24 weeks. RESULTS: The SGRQ in the active group was 59.9 (SE, 2.0) at study entry (n = 36), 47.4 (SE, 2.3) at 12 weeks (n = 32), and 50.6 (SE, 2.5) at 24 weeks (n = 24). The SGRQ in the control group was 59.3 (SE, 2.5) at study entry and did not change significantly over 24 weeks. There was a difference of 10.4 points (confidence interval [CI], 3.6 to 17.3) between the two groups at 12 weeks ($p < 0.001$) and of 8.1 points (CI, 1.4 to 14.9) at 24 weeks ($p = 0.02$) in favor of the active group. CONCLUSIONS: A 6-week outpatient-based program significantly improved quality of life in patients with moderate-to-severe COPD. Benefit was still evident after 24 weeks.

Geographic Variation in Long-Term Oxygen Therapy in Denmark: Factors Related to Adherence to Guidelines for Long-Term Oxygen Therapy—Ringbaek TJ, Lange P, Viskum K. Chest 2001;119(6):1711–1716.

Study objectives: To evaluate regional differences in adherence to guidelines for long-term oxygen therapy (LTOT) in Denmark and to determine factors related to compliance with these guidelines. DESIGN: Cross-sectional study and analysis of a nationwide database (Danish Oxygen Register). SETTING: Denmark. PATIENTS: In November 1994, 1,354 COPD patients were receiving LTOT in Denmark. Measurements and results: Among 16 counties, the prevalence of LTOT for COPD varied from 14 to 53 per 100,000. The prevalence was highest in counties where general practitioners (GPs) were prescribing LTOT. Adherence to national guidelines for LTOT was found in 34.4% of the patients for the whole of Denmark and varied regionally from 14 to 63%. Mean compliance with guidelines was 5.3 (range, 2.9 to 9.1) times as likely if the oxygen was prescribed by a pulmonary department compared to LTOT initiated by a GP. CONCLUSIONS: Marked geographic variations in compliance with LTOT guidelines are present even in a small country as Denmark. In general, the adherence to the guidelines is poor, especially when non-chest physicians prescribe LTOT. We therefore recommend that local and national thoracic societies together with health organizations responsible for treatment should play a more forceful role in implementing the guidelines. This could be done by enhanced educational efforts, by monitoring of adherence, or even by centralizing the prescription right to departments with pulmonary physicians.

Influenza Pneumonia: A Descriptive Study—Oliveira EC, Marik PE, Colice G. Chest 2001;119(6):1717–1723.

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OBJECTIVE: To describe the clinical features and complications of patients hospitalized with influenza during the 1999–2000 influenza season. METHODS: We reviewed all cases of patients with influenza admitted to a large metropolitan referral hospital during the 1999–2000 season. RESULTS: Thirty-five adult patients (15 men and 20 women) tested positive for influenza A by direct enzyme immunoassay. A fourfold to sevenfold increase in the number of influenza cases was observed over previous years. Most patients had serious comorbid illnesses (88%), such as diabetes and chronic respiratory and heart disease. Seventeen patients developed pneumonia; these patients tended to be older (mean ± SD, 63 ± 13 years vs 51 ± 19 years, respectively; $p = 0.04$) and had a higher incidence of chronic lung disease (41% vs 6%, respectively; $p = 0.02$) than the patients without pneumonia. Shortness of breath was the only symptom that distinguished patients with pneumonia from those with an upper respiratory tract illness alone. Antiviral treatment was begun 4 ± 3 days from initiation of symptoms in patients with pneumonia and consisted of oseltamivir (35.2%), rimantadine (5.8%), or a combination of both (17.6%). Respiratory and/or blood culture results were positive in five patients (29%). *Staphylococcus aureus* was isolated in five patients, and *Streptococcus pneumoniae* was isolated in one patient. Ten of the patients with pneumonia (58.8%) were admitted to the ICU, and 5 patients (29%) died. The length of ICU stay and mechanical ventilation were 28 ± 26 days and 21.5 ± 20.5 days, respectively. Death in most pneumonia patients was attributed to respiratory failure. CONCLUSION: The recognized number of hospital admissions for influenza increased fourfold to sevenfold over previous years, most likely due to the implementation of rapid diagnostic tests for influenza. Patients with signs and symptoms of influenza and shortness of breath should undergo chest radiography. Hospitalization of patients with influenza pneumonia occurred in both previously healthy and immunocompromised patients and had a high mortality. S aureus was the most common bacterial isolate in patients with influenza pneumonia. Empiric antibiotics with staphylococcal activity should be used pending culture results in patients with influenza pneumonia. The effectiveness of oseltamivir and rimantadine in treating patients with influenza pneumonia remains to be determined.

Strategies Incorporating Spiral CT for the Diagnosis of Acute Pulmonary Embolism: A Cost-Effectiveness Analysis—Paterson DI, Schwartzman K. Chest 2001;119(6):1791–1800.

OBJECTIVE: To assess the cost-effectiveness of spiral CT for the diagnosis of acute pulmonary embolism. DESIGN: Computer-based cost-effectiveness analysis. PATIENTS: Simulated cohort of 1,000 patients with suspected acute pulmonary embolism (PE), with a prevalence of 28.4%, as in the Prospective Investigation of Pulmonary Embolism Diagnosis study. INTERVENTIONS: Using a decision-analysis model, seven diagnostic strategies were compared, which incorporated combinations of ventilation-perfusion ($\dot{V}/\dot{Q}$)scans, duplex ultrasound of the legs, spiral CT, and conventional pulmonary angiography. Measurements and results: Expected survival and cost (in Canadian dollars) at 3 months were estimated. Four of the strategies yielded poorer survival at higher cost. The three remaining strategies were as follows: (1) $\dot{V}/\dot{Q}$ ± leg ultrasound ± spiral CT, with an expected survival of 953.4 per 1,000 patients and a cost of $1,391 per patient; (2) $\dot{V}/\dot{Q}$ ± leg ultrasound ± pulmonary angiography (the "traditional" algorithm), with an expected survival of 953.7 per 1,000 patients and a cost of $1,416 per patient; and (3) spiral CT ± leg ultrasound, with an expected survival of 958.2 per 1,000 patients and a cost of $1,751 per patient. The traditional algorithm was then excluded by extended dominance. The cost per additional life saved was $70,833 for spiral CT ± leg ultrasound relative to $\dot{V}/\dot{Q}$ ± leg ultrasound ± spiral CT. CONCLUSIONS: Spiral CT can replace pulmonary angiography in patients with nondiagnostic $\dot{V}/\dot{Q}$ scan and negative leg ultrasound findings. This approach is likely as effective as-and possibly less expensive than-the current algorithm for diagnosis of acute PE. When spiral CT is the initial diagnostic test, followed by leg ultrasound, expected survival improves but costs are also considerably higher. These findings were robust to variations in the assumed sensitivity and specificity of spiral CT.

Treatment Effects on Carbon Dioxide Retention in Patients with Obstructive Sleep Apnea-Hypopnea Syndrome—Han F, Chen E, Wei H, He Q, Ding D, Strohl KP. Chest 2001;119(6):1814–1819.

OBJECTIVES: This study was designed to examine respiratory control in patients with obstructive sleep apnea-hypopnea syndrome (OSAHS), with or without CO_2 retention. METHODS: We recruited 10 body mass index-matched, apnea-hypopnea index-matched, age-matched, and lung function-matched OSAHS patients, according to their awake P_{aCO_2}. Five patients were hypercapnic (P_{aCO_2}, ≥ 45 mm Hg), and five patients were eucapnic. Hypoxic responses (the ratio of the change in minute ventilation $\Delta\dot{V}_E$ to the change in arterial oxygen saturation [ΔS_{aO_2}] and the ratio of the change in mouth occlusion pressure over the first 100 ms of inspiration against an occluded airway [$\Delta P_{0.1}$] to ΔS_{aO_2}) and hypercapnic responses ($\Delta\dot{V}_E/\Delta P_{CO_2}$ ratio and $\Delta P_{0.1}/\Delta P_{CO_2}$ ratio) were tested during wakefulness before treatment in all 10 patients, and before and during treatment (at 2, 4, and 6 weeks) with pressure support in the hypercapnic group. RESULTS: Hypercapnic patients had lower mean (± SD) $\Delta V_E/\Delta S_{aO_2}$ ratio than eucapnic patients (-0.17 ± 0.04 vs -0.34 ± 0.04 L/min/%S_{aO_2}, respectively), lower mean $\Delta P_{0.1}/\Delta S_{aO_2}$ ratio (-0.04 ± 0.02 vs -0.14 ± 0.03 cm H_2O/%S_{aO_2}, respectively), and lower $\Delta P_{0.1}/\Delta P_{CO_2}$ ratio (0.23 ± 0.1 vs 0.49 ± 0.1 cm H_2O/mm Hg, respectively) [$p < 0.05$]. After receiving noninvasive ventilation treatment, the hypercapnic and hypoxic responses of the hypercapnic patients increased. At 4 to 6 weeks, values for both responses had increased to within the normal range and P_{aCO_2} had fallen to < 45 mm Hg, while weight was unchanged. CONCLUSIONS: Depressed chemoresponsiveness plays a role that is independent of obesity in the development of CO_2 retention in some OSAHS patients, and it may be a response to sleep-disordered breathing.

Underestimation of Nocturnal Hypoxemia due to Monitoring Conditions in Patients with COPD—Brijker F, van Den Elshout FJ, Heijdra YF, Folgering HT. Chest 2001;119(6):1820–1826.

Study objectives: COPD patients run a risk of developing nocturnal oxygen desaturation. When evaluating patients with nocturnal hypoxemia, an unfamiliar hospital environment and the monitoring equipment may cause sleep disturbances. It was hypothesized that increased sleep disruption will lead to fewer instances of desaturation during a night of monitoring. DESIGN:The following forms of monitoring were evaluated prospectively on 3 nights for each patient: oximetry at home; polysomnography (PSG) at home; and PSG in the hospital. SETTING: Department of Pulmonology, Rijnstate Hospital Arnhem, The Netherlands. PATIENTS: Fourteen stable COPD patients (7 men; median age, 71.5 years; age range, 59 to 81 years; FEV_1, 32.5% predicted; FEV_1 range, 19 to 70% predicted) participated in the study. All subjects had significant instances of nocturnal arterial oxygen desaturation. Those patients with a sleep-related breathing disorder or cardiac failure were excluded from the study. Measurements and results: The mean nocturnal arterial oxygen saturation (S_{aO_2}) level was higher during PSG monitoring at home (89.7%; range, 77 to 93%) than during oximetry monitoring (88.5%; range, 80 to 92%) [$p < 0.025$]. The fraction of time spent in hypoxemia (ie, $S_{aO_2} <$ 90%) was lower during PSG monitoring at home (40.8%; range, 5 to 100%) than during oximetry monitoring (59.9%; range, 6 to 100%) [$p < 0.01$]. Desaturation time ($\Delta S_{aO_2} > 4\%$) was lower during PSG monitoring at home (22.1%; range, 3 to 63%) during PSG monitoring at home than during oximetry monitoring (50.4%; range, 4 to 91%) [$p < 0.01$]. A correction for actual sleep during PSG monitoring reduced the differences between PSG monitoring at home and oximetry monitoring, although a difference in the desaturation time remained (PSG monitoring at home, 31.9% [range, 2 to 75%]; oximetry monitoring, 50.4% [range,

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4 to 91%]) [p = 0.041]. A comparison of sleep architectures for nights when PSG was being monitored showed a higher arousal index in the hospital than at home (PSG monitoring in the hospital, 5.6 arousals per hour [range, 2 to 16 arousals per hour]; PSG monitoring at home, 2.5 arousals per hour [range, 1 to 6 arousals per hour]) [$p < 0.025$], but no differences in S_{aO_2} levels were found between PSG monitoring at home and PSG monitoring in the hospital. CONCLUSION: The artifacts due to sleep-monitoring equipment may cause an underestimation of the degree of nocturnal hypoxemia in COPD patients. The addition of an unfamiliar environment causes more sleep disruption, but this does not affect nocturnal S_{aO_2} levels further.

Row-A-Boat Phenomenon: Respiratory Compensation in Advanced Duchenne Muscular Dystrophy—Yasuma F, Kato T, Matsuoka Y, Konagaya M. Chest 2001;119(6):1836–1839.

BACKGROUND: "Row-a-boat" phenomenon (RBP) is a spontaneous upper-body movement in patients with advanced Duchenne muscular dystrophy (DMD), when sitting upright supported by a belt around the body in a wheelchair. However, the role of RBP has not been clarified. OBJECTIVES: To support the hypothesis that RBP is an abnormal pattern of respiration to compensate for the atrophied respiratory muscles in advanced DMD. Patients and methods: Age, degree of ventilator dependency, and blood gas and spirometry values of 12 patients with spontaneous RBP were compared to those of 8 patients without RBP. All patients were men, and all exhibited a comparable level of motor function (unable to ambulate). Spirometry was undertaken with an ambulatory pneumotachograph in six patients with RBP in two conditions: sitting with RBP and sitting without RBP. In the latter condition, because a patient's shoulders, neck, and head were manually restricted, RBP was prevented. RESULTS: We found that the patients with RBP were older (mean, 25.98 years vs 19.84 years), more dependent on mechanical ventilation (13.96 h/d vs 4.31 h/d), and had lower FVC and percentage of FVC (511.3 mL vs 762.5 mL and 13.37% vs 20.11%, respectively) than those without RBP. We also found that the frequency of RBP was identical with tidal breathing, and FVC was increased by 50.8% by simply allowing RBP. CONCLUSION: We conclude that RBP is a respiratory movement to compensate for the atrophied respiratory muscles in advanced DMD.

Predictors of Outcome for Patients with COPD Requiring Invasive Mechanical Ventilation—Nevins ML, Epstein SK. Chest 2001;119(6):1840–1849.

INTRODUCTION: Accurate outcomes data and predictors of outcomes are fundamental to the effective care of patients with COPD and in guiding them and their families through end-of-life decisions. DESIGN: We conducted a retrospective cohort study of 166 patients using prospectively gathered data in patients with COPD who required mechanical ventilation for acute respiratory failure of diverse etiologies. RESULTS: The in-hospital mortality rate for the entire cohort was 28% but fell to 12% for patients with a COPD exacerbation and without a comorbid illness. Univariate analysis showed a higher mortality rate among those patients who required > 72 h of mechanical ventilation (37% vs 16%; $p < 0.01$), those without previous episodes of mechanical ventilation (33% vs 11%; $p < 0.01$), and those with a failed extubation attempt (36% vs 7%; $p = 0.0001$). With multiple logistical regression, higher acute physiology score measured 6 h after the onset of mechanical ventilation, presence of malignancy, presence of APACHE (acute physiology and chronic health evaluation) II-associated comorbidity, and the need for mechanical ventilation ≥ 72 h were independent predictors of poor outcome. CONCLUSIONS: We conclude that among variables available within the first 6 h of mechanical ventilation, the presence of comorbidity and a measure of the severity of the acute illness are predictors of in-hospital mortality among patients with COPD and acute respiratory failure. The occurrence of extubation failure or the need for mechanical ventilation beyond 72 h also portends a worse prognosis.

Do Blood Transfusions Improve Outcomes Related to Mechanical Ventilation?—Hebert PC, Blajchman MA, Cook DJ, Yetisir E, Wells G, Marshall J, Schweitzer I. Chest 2001;119(6):1850–1857.

BACKGROUND: Correcting the decrease in oxygen delivery from anemia using allogeneic RBC transfusions has been hypothesized to help with increased oxygen demands during weaning from mechanical ventilation. However, it is also possible that transfusions hinder the process because RBCs may not be able to adequately increase oxygen delivery. In this study, we determined whether a liberal RBC transfusion strategy improved outcomes related to mechanical ventilation. METHODS: Seven hundred thirteen patients receiving mechanical ventilation, representing a subgroup of patients from a larger trial, were randomized to either a restrictive transfusion strategy, receiving allogeneic RBC transfusions at a hemoglobin concentration of 7.0 g/dL (and maintained between 7.0 g/dL and to 9.0 g/dL), or to a liberal transfusion strategy, receiving RBCs at 10.0 g/dL (and maintained between 10.0 g/dL and 12.0 g/dL). The larger trial was designed to evaluate transfusion practice rather than weaning per se. RESULTS: Baseline characteristics in the restrictive-strategy group (n = 357) and the liberal-strategy group (n = 356) were comparable. The average durations of mechanical ventilation were 8.3 ± 8.1 days and 8.3 ± 8.1 days (95% confidence interval [CI] around difference, - 0.79 to 1.68; $p = 0.48$), while ventilator-free days were 17.5 ± 10.9 days and 16.1 ± 11.4 days (95% CI around difference, - 3.07 to 0.21; $p = 0.09$) in the restrictive-strategy group vs the liberal-strategy group, respectively. Eighty-two percent of the patients in the restrictive-strategy group were considered successfully weaned and extubated for at least 24 h, compared to 78% for the liberal-strategy group ($p = 0.19$). The relative risk (RR) of extubation success in the restrictive-strategy group compared to the liberal-strategy group, adjusted for the confounding effects of age, APACHE (acute physiology and chronic health evaluation) II score, and comorbid illness, was 1.07 (95% CI, 0.96 to 1.26; $p = 0.43$). The adjusted RR of extubation success associated with restrictive transfusion in the 219 patients who received mechanical ventilation for > 7 days was 1.1 (95% CI, 0.84 to 1.45; $p = 0.47$). CONCLUSION: In this study, there was no evidence that a liberal RBC transfusion strategy decreased the duration of mechanical ventilation in a heterogeneous population of critically ill patients.

The Efficacy of Postoperative Incentive Spirometry Is Influenced by the Device-Specific Imposed Work of Breathing—Weindler J, Kiefer RT. Chest 2001;119(6):1858–1864.

Study objectives: The study evaluated the impact of the additional imposed work of breathing (WB_{imp}) generated by two different spirometers on postoperative incentive spirometry performance in patients at high risk and moderate risk for postoperative pulmonary complications (PPCs). Additionally, we investigated whether maximal inspiratory pressure (PI_{max}) is an easy estimate of the WB_{imp} imposed by incentive spirometers. DESIGN: Prospective, randomized, single-blind clinical trial. SETTING: ICU of a university hospital. Interventions and measurements: Thirty male patients were assigned to a group at high risk for PPCs (group A: inspiratory capacity [IC], q 1.6 L) or to a group at moderate risk for PPCs (group B; IC, 1.6 to 2.5 L) after upper-abdominal, thoracic, or two-cavity surgery. On the first or second postoperative day WB_{imp}, IC, and PI_{max} were recorded without spirometers (baseline) and during incentive spirometry with the Mediflo spirometer (Medimex; Hamburg, Germany) (high WB_{imp}) and the Coach spirometer (Kendall; Neustadt, Germany) (low WB_{imp}) using a pneumotachograph. In group A, the baseline and the ICs for both spirometers only differed slightly. In group B, the IC was significantly reduced for the Mediflo ($p < 0.05$), which imposed a WB_{imp} twice as high as the Coach ($p < 0.01$). PI_{max} was

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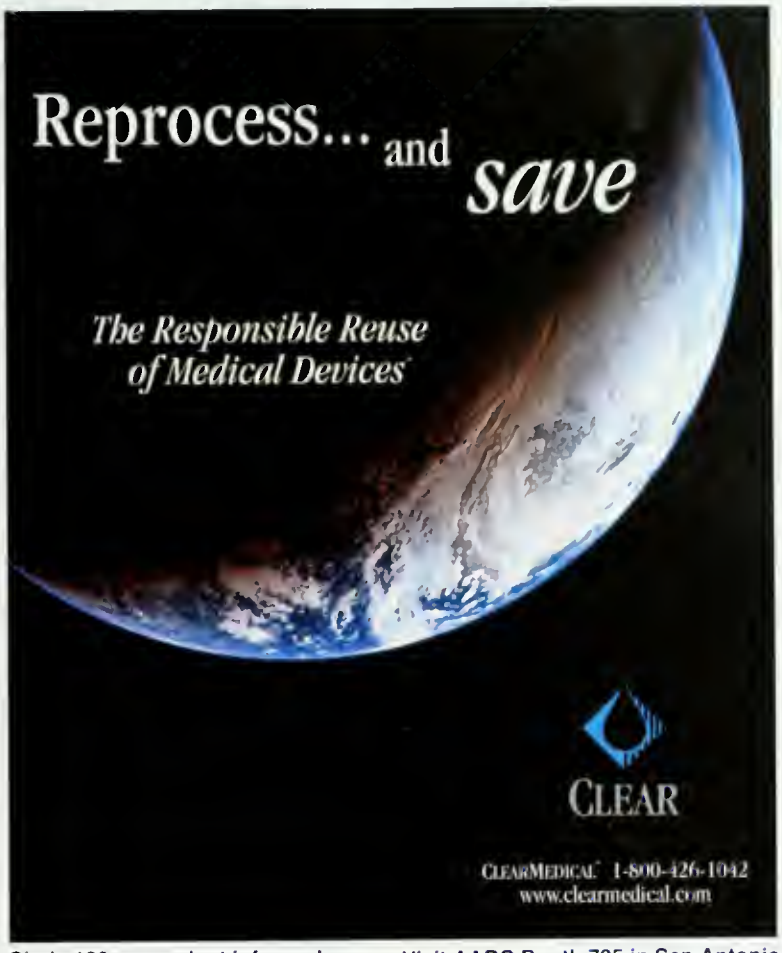

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significantly increased for both the Mediflo and the Coach ($p < 0.01$). PI_{max} was positively correlated with WB_{imp} ($r = 0.8$). CONCLUSIONS: Incentive spirometers differ considerably in their additional WB_{imp} with a potential impact on the efficacy of postoperative incentive spirometry performance. PI_{max} might be an easy clinical estimate for the WB_{imp} during incentive spirometry. Incentive spirometers with low WB_{imp} permit increased maximal sustained inspiration and, thus, enhanced incentive spirometry performance, and, therefore, it might be more suitable for use in postoperative respiratory care.

Auditory Detection of Simulated Crackles in Breath Sounds—Kiyokawa H, Greenberg M, Shirota K, Pasterkamp H. Chest 2001;119(6): 1886–1892.

BACKGROUND: Computerized analysis of breath sounds has relied on human auditory perception as the reference standard for identifying crackles. In this study, we tested the human audibility of crackles by superimposing artificial clicks on recorded breath sounds and having physicians listen to the recordings to see if they could identify the crackles. OBJECTIVES: To establish the audibility of simulated crackles introduced in breath sounds of different intensity, to study the effects of crackle characteristics on their audibility, and to investigate crackle detection within and between observers. METHODS: Fine, medium, and coarse crackles with large and small amplitude were synthesized by computer software. Waveform parameters were based on published characteristics of lung sound crackles. The amplitude for small crackles was defined as just above the threshold of audibility for simulated crackles inserted in sound recorded during breath hold. Simulated crackles were then superimposed on breath sounds recorded at 0 L/s (breath hold), 1 L/s, and 2 L/s airflow. Five physicians listened during playback on two separate occasions to determine if crackles could be heard and to calculate the interobserver and intraobserver variations. RESULTS: Failed detection of crackles was significantly more common in the following conditions: (1) background breath sounds had higher intensity (2 L/s airflow) compared to lower intensity (1 L/s), (2) crackle type was coarse or medium compared to fine, and (3) crackle amplitude was small compared to large. Both intraobserver and interobserver agreements were high ($\kappa > 0.6$). RELEVANCE: The validation of automated techniques for crackle detection in lung sound analysis should not rely on auscultation as the only reference. Detection of crackles is facilitated when patients take slow, deep breaths that generate little breath sounds.

Talc Preparations Used for Pleurodesis Vary Markedly from One Preparation to Another—Ferrer J, Villarino MA, Tura JM, Traveria A, Light RW. Chest 2001;119(6):1901–1905.

BACKGROUND: At the present time, talc is the one of the agents most commonly used for the production of a pleurodesis. However, there have been several recent reports of acute pneumonitis developing after the intrapleural administration of talc. The incidence of pneumonitis has varied markedly from center to center. OBJECTIVE: To compare the physical characteristics of talc used for the production of pleurodesis in various localities. DESIGN: Eight talc preparations (four from the United States, and one each from Brazil, France, Spain, and Taiwan) were analyzed for the distribution of the particle size and the type and amount of impurities. MEASUREMENTS: The physical characteristics of the talc specimens were determined using radiograph diffraction and scanning electron microscopy. RESULTS: The mean and median particle size varied by more than a factor of three among the eight different talc preparations. In addition, the impurities of the different talc preparations were quite varied. CONCLUSIONS: We conclude that there is marked variation in the physical characteristics of the talc preparations used intrapleurally for the production of a pleurodesis. We speculate that different incidences of acute pneumonitis at various centers after intrapleural administration of talc may be due to differences in the physical characteristics of the talc preparations used for pleurodesis.

Do All Patients Require Supplemental Oxygen During Flexible Bronchoscopy?—Jones AM, O'Driscoll R. Chest 2001;119(6):1906–1909.

Study objectives: Some respiratory units routinely administer supplemental oxygen to all patients during flexible bronchoscopy, but other units give oxygen only to those who desaturate (arterial oxygen saturation [S_{aO_2}], < 90%). We performed a study to examine both the requirement for supplemental oxygen and the effect of I.V. midazolam therapy on oxygenation during flexible bronchoscopy for patients with a known FEV_1. DESIGN: Data on the S_{aO_2} of patients during flexible bronchoscopy were collected prospectively for all procedures performed in our respiratory unit for the period 1992 to 1997. RESULTS: There were 1,051 flexible bronchoscopy procedures performed in which the patient had a known FEV_1 and was not receiving supplemental oxygen before the procedure. Supplemental oxygen was commenced during or immediately after the procedure in 151 cases (14.4%), while a further 101 cases (9.6%) had momentary desaturation (ie, < 20 s) not requiring oxygen therapy. The lower the FEV_1, the greater the risk of significant desaturation and the need for supplemental oxygen ($p < 0.0001$) (supplemental O_2 therapy was administered in 35% of cases if $FEV_1 < 1.0$ L, in 14% of cases if FEV_1 was 1.0 to 1.5 L, and in 7% of cases if $FEV_1 > 1.5$ L). The use of low-to-moderate doses of midazolam as sedation did not affect the probability of the occurrence of significant desaturation ($p = 0.204$). CONCLUSIONS: This study supports guidelines that suggest that all patients should be monitored by pulse oximetry during flexible bronchoscopy. Desaturation may occur at any FEV_1 level even without sedation. The majority of our patients did not require routine oxygen supplementation, especially the group with an FEV_1 above 1 L.

Successful Bronchoscopic Placement of Tracheobronchial Stents Without Fluoroscopy—Herth F, Becker HD, LoCicero J 3rd, Thurer R, Ernst A. Chest 2001;119(6):1910–1912.

BACKGROUND: Tracheobronchial stenting is performed increasingly often. Fluoroscopic control, which leads to significant radiation exposure for patients and staff, is recommended for the placement of metal stents. METHODS: All consecutive patients referred to two airway centers in need of airway stenting who received stents (Ultraflex; Boston Scientific, Natick, MA) underwent placement using endoscopic guidance only. All data were collected in an ongoing continuous database. RESULTS: One hundred stents were placed in 96 patients for central airway obstruction, and the data were reviewed. Stents were placed in all locations within the central airways for a variety of indications but mainly for malignant obstruction. No complications occurred, and all stents were placed satisfactorily. CONCLUSION: At centers with dedicated airway teams, Ultraflex stents can be quickly and safely inserted without the need for fluoroscopy. This saves radiation exposure to patients and to staff and may lead to a more cost-effective procedure.

Status Asthmaticus in Children: A Review—Werner HA. Chest 2001; 119(6):1913–1929.

About 10% of American children have asthma, and its prevalence, morbidity, and mortality have been increasing. Asthma is an inflammatory disease with edema, bronchial constriction, and mucous plugging. Status asthmaticus in children requires aggressive treatment with beta-agonists, anticholinergics, and corticosteroids. Intubation and mechanical ventilation should be avoided if at all possible, as the underlying dynamic hyperinflation will worsen with positive-pressure ventilation. If mechanical ventilation becomes necessary, controlled hypoventilation with low tidal volume and long expiratory time may lessen the risk of barotrauma

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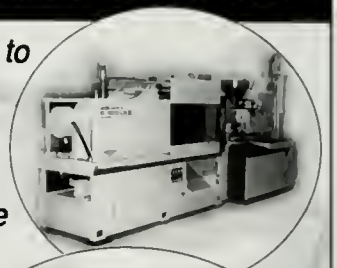

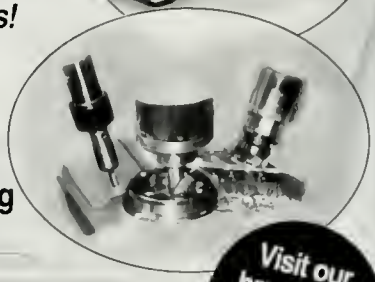

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and hypotension. Unusual and nonestablished therapies for severe asthma are discussed.

Motivating Factors in Futile Clinical Interventions—Rivera S, Kim D, Garone S, Morgenstern L, Mohsenifar Z. Chest 2001;119(6):1944–1947.

With modern medical technology, it is now possible to sustain life for prolonged periods in critically ill patients, even when there is no reasonable hope of improvement or achieving the goals of therapy. Such futile and medically inappropriate interventions may violate both the ethical and medical precepts generally accepted by patients, families, and physicians. In this study, we sought to determine who was primarily responsible for such interventions, the nature of their motivation, and the role of a timely bioethical consultation. In a retrospective review, we identified 100 patients of 331 bioethical consultations who had futile or medically inappropriate therapy. The average age of patients was 73.5 ± 32 years (mean ± 2 SD) with 57% being male. Fifty-seven percent of the patients were admitted to the hospital with a degenerative disorder, 21% with an inflammatory disorder, and 16% with a neoplastic disorder. The family was responsible for futile treatment in 62% of cases, the physician in 37% of cases, and a conservator in one case. Unreasonable expectation for improvement was the most common underlying factor. Family dissent was involved in 7 of 62 cases motivated by family, but never when physicians were primarily responsible. Liability issues motivated physicians in 12 of 37 cases where they were responsible but in only 1 of 62 cases when the family was (chi^2 5 degrees of freedom = 26.7, $p < 0.001$). When the bioethics consultation resulted in cessation of the therapy, patients died in a median of 2 days as opposed to 16 days if therapy continued ($p < 0.001$).

Short-Term and Long-Term Outcomes After Bilateral Lung Volume Reduction Surgery: Prediction by Quantitative Ct—Flaherty KR, Kazerooni EA, Curtis JL, Iannettoni M, Lange L, Schork MA, Martinez FJ. Chest 2001;119(5):1337–1346.

OBJECTIVES: To evaluate selection criteria and duration of benefit for patients undergoing lung volume reduction surgery (LVRS). METHODS: Eighty-nine consecutive patients with severe emphysema who underwent bilateral LVRS were prospectively followed up for up to 3 years. Patients underwent preoperative pulmonary function testing, 6-min walk, chest CT, and answered a baseline dyspnea questionnaire. CT scans in 65 patients were analyzed for emphysema extent and distribution using the percentage of emphysema in the lung, percentage of normal lower lung, and the CT emphysema ratio (CTR, an index of the craniocaudal distribution of emphysema). All patients underwent at least 6 weeks of pulmonary rehabilitation prior to surgery. Outcome measures were FEV_1 6-min walk distance, and transitional dyspnea index (TDI). RESULTS: Compared to baseline, FEV_1 was significantly increased at 3, 6, 12, 18, 24, and 36 months after surgery ($p \leq 0.008$). The 6-min walk distance increased from 871 feet (baseline) to 1,110 feet (3 months), 1,214 feet (6 months), 1,326 feet (12 months), 1,342 feet (18 months), 1,371 feet (24 months), and 1,390 feet (36 months) after surgery. Despite a decline in FEV_1over time, 6-min walk distance was preserved. Dyspnea as measured by TDI improved at 3, 6, 12, 18, 24, and 36 months after surgery. A high CTR was the best predictor of a 12% increase over baseline and an absolute increase of 200 mL in FEV_1, although with a low area under the receiver operating characteristic curve. In addition, the sensitivity and negative predictive value of the CTR were limited. No radiographic or physiologic predictor was able to consistently predict a successful increase in walk distance or TDI. CONCLUSION: LVRS improves pulmonary function, decreases dyspnea, and enhances exercise capacity in many patients with severe emphysema, although improvement wanes 36 months after surgery.

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Bupropion for Smoking Cessation: Predictors of Successful Outcome—Dale LC, Glover ED, Sachs DP, Schroeder DR, Offord KP, Croghan IT, Hurt RD. Chest 2001;119(5):1357–1364.

OBJECTIVES: To identify predictors of smoking abstinence at the end of medication use that could assist in the optimal use of a sustained-release (SR) form of bupropion for treating cigarette smokers. DESIGN: A double-blind, placebo-controlled, dose-response trial. SETTING: Multicenter (three sites) study conducted in the United STATES: PARTICIPANTS: Six hundred fifteen healthy men and women (≥ 18 years of age) who were smoking ≥ 15 cigarettes per day and who were motivated to stop smoking. INTERVENTION: Random assignment of patients to placebo or SR bupropion treatment, 100, 150, or 300 mg/d, for 7 weeks (total duration of study was 52 weeks: 7 weeks of treatment and 45 weeks of follow-up). Measurements and results: Logistic regression was used to identify predictors of abstinence at the end of the medication phase. Univariate predictors included the following: bupropion dose ($p < 0.001$); older age ($p = 0.024$); lower number of cigarettes smoked per day (cpd) ($p < 0.001$); lower Fagerstrom Tolerance Questionnaire score ($p = 0.011$); longest time previously abstinent that was < 24 h or > 4 weeks ($p < 0.001$); absence of other smokers in the household ($p = 0.021$); greater number of previous stop attempts ($p = 0.019$); and study site ($p = 0.004$). Multivariate predictors of abstinence at the end of the medication phase were the following: higher bupropion dose ($p < 0.001$); lower number of cpd ($p < 0.001$); longest time previously abstinent from smoking ($p = 0.002$); male gender ($p = 0.014$); and study site ($p = 0.021$). CONCLUSION: Bupropion SR therapy was effective in treating cigarette smokers independently of all other characteristics studied. Lower smoking rate, brief periods (ie, < 24 h) or long periods (ie, > 4 weeks) of abstinence with previous attempts to stop smoking, and male gender were predictive of better outcomes, independent of the dose of bupropion that was used.

Smoking Characteristics: Differences in Attitudes and Dependence Between Healthy Smokers and Smokers with COPD—Jimenez-Ruiz CA, Masa F, Miravitlles M, Gabriel R, Viejo JL, Villasante C, Sobradillo V. Chest 2001;119(5):1365–1370.

OBJECTIVE: To ascertain the differences in smoking characteristics between a group of smokers with COPD and another group of healthy smokers, both of which were identified in a population-based epidemiologic study. Design and participants: This is an epidemiologic, multicenter, population-based study conducted in seven areas of SPAIN: A total of 4,035 individuals, men and women aged 40 to 69 years, who were selected randomly from a target population of 236,412 subjects, participated in the study. INTERVENTIONS: Eligible subjects answered the European Commission for Steel and Coal questionnaire. Spirometry was performed followed by a bronchodilator test when bronchial obstruction was present. The Fagerstrom questionnaire was used for study of the degree of physical nicotine dependence, and the Prochazka model was followed for analysis of the smoking cessation phase. RESULTS: Of 1,023 active smokers, 153 (15%) met the criteria for COPD. Smokers with COPD were more frequently men (odds ratio [OR], 2.18; 95% confidence interval [CI], 1.21 to 3.95), were ≥ 46 years of age (OR, 1.97; 95% CI, 1.18 to 3.31), had a lower educational level (OR, 1.96; 95% CI, 1.23 to 3.14), and had smoked > 30 pack-years (OR, 3.70; 95% CI, 2.42 to 5.65). Smokers with COPD showed a higher dependence on nicotine than healthy smokers (mean [± SD] Fagerstrom test score, 4.77 ± 2.45 vs 3.15 ± 2.38, respectively; $p < 0.001$) and higher concentrations of CO in exhaled air (mean concentration, 19.7 ± 16.3 vs 15.4 ± 12.1 ppm, respectively; $p < 0.0001$). Thirty-four percent of smokers with COPD and 38.5% of smokers without COPD had never tried to stop smoking. CONCLUSIONS: Smokers with COPD have higher tobacco consumption, higher dependence on nicotine, and higher concentrations of CO in exhaled air, suggesting a different pattern of cigarette smoking. Cases of COPD among smokers predominate in men and in individuals with lower educational levels. A significant proportion of smokers have never tried to stop smoking; thus, advice on cessation should be reinforced in both groups of smokers.

Noninvasive Mechanical Ventilation Improves Endurance Performance in Patients with Chronic Respiratory Failure Due to Thoracic Restriction—Schonhofer B, Wallstein S, Wiese C, Kohler D. Chest 2001;119(5):1371–1378.

OBJECTIVE: Treatment with noninvasive mechanical ventilation (NMV) alleviates hypoventilation and improves gas exchange in patients with chronic respiratory failure (CRF) due to thoracic restriction. However, little is known about the effects of NMV on respiratory and peripheral muscle endurance. DESIGN: Prospective case-control study. SUBJECTS: Ten patients in clinically stable condition (age, 53.5 ± 8.2 years [mean ± SD]) with mild-to-moderate CRF due to thoracic restriction (P_{CO_2} between 45 mm Hg and 55 mm Hg) were treated with NMV during the night for 3 months. Ten matched patients (age, 52.2 ± 9.5 years) receiving 3 months of normal care without NMV served as a control group. Intervention and measurements: After a 3-day period of familiarization with the endurance tests, all patients performed a baseline preintervention inspiratory threshold loading test, cycle ergometer test, and shuttle walking test on the same day. The endurance tests were then repeated following the 3-month intervention period. RESULTS: NMV was used on average for 7.1 ± 0.9 h/d during the 3-month period. There was a significant improvement in endurance time ($p < 0.0001$) in all three endurance tests in the NMV group compared with the control group. In the NMV group, endurance time increased by 278 ± 269% during the inspiratory threshold loading test, by 176 ± 159% during the cycle ergometer test, and by 32 ± 22% during the shuttle walking test. Significant improvements ($p < 0.01$) in both P_{O2} and P_{CO_2} were also observed in the NMV group but not in the control group. CONCLUSIONS: Three months of treatment with NMV increases both respiratory and peripheral muscle endurance in patients with CRF due to thoracic restriction.

Is It Safe for Patients with Chronic Hypercapnic Respiratory Failure Undergoing Home Noninvasive Ventilation to Discontinue Ventilation Briefly?—Karakurt S, Fanfulla F, Nava S. Chest 2001;119(5):1379–1386.

Study objectives: A brief discontinuation (< 1 week) of long-term ventilation may be necessary in patients who are not totally ventilator-dependent in cases of technical problems, intolerable nasal irritation, upper airway congestion, or travel. We examined the incidence, timing, and causes of possible clinical deterioration after a brief withdrawal of ventilation in patients with chronic respiratory failure (CRF) who were well-established on long-term noninvasive mechanical ventilation (NIMV). Study design: Prospective clinical study. PATIENTS: Eleven inpatients in clinically stable condition (COPD, 6 patients; and restrictive thoracic disease [RTD], 5 patients) who had severe CRF (P_{aCO_2}, > 50 mm Hg) and had been receiving NIMV for (mean ± SD) 19.3 ± 5.3 months were enrolled. Interventions and measurements: Arterial blood gas (ABG) levels, maximal inspiratory pressure (PI_{max}), breathing pattern, dyspnea rating, and life symptoms (measured by a questionnaire) were recorded daily after NIMV withdrawal for 6 days or until the patients showed clinical and/or ABG level deterioration. Pulmonary function tests were performed and neuromuscular drive was measured at the beginning and the end of the study. RESULTS: Five of the 11 patients (45.4%) [COPD, 3 patients; and RTD, 2 patients] were reconnected to a ventilator before the scheduled time because of ABG level deterioration. Despite these changes, none of the patients reported severe worsening of symptoms or other medical complications. The patients whose ABG levels worsened had statistically significant decreases in tidal volume and PI_{max}, suggesting that the development of alveolar hypoventilation was related to re-

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spiratory muscle weakness. CONCLUSIONS: A brief discontinuation of NIMV in patients who were affected by chronic hypercapnic respiratory failure and were well-established on NIMV is associated with a relatively high incidence of ABG level worsening due to the development of alveolar hypoventilation. If NIMV must be briefly interrupted for clinical reasons, the patient should be monitored closely for abrupt worsening, and prompt technical intervention should be provided if a ventilator fails.

Unreliability of Automatic Scoring of MESAM 4 in Assessing Patients with Complicated Obstructive Sleep Apnea Syndrome—Cirignotta F, Mondini S, Gerardi R, Mostacci B, Sancisi E. Chest 2001; 119(5):1387–1392.

BACKGROUND: Portable devices are used for unattended recording of patients with suspected obstructive sleep apnea syndrome (OSAS). The MESAM 4 (MAP; Martinsried, Germany) is a computerized ambulatory polysomnographic system that records four parameters: breathing noise, heart rate, arterial oxygen saturation (S_{aO_2}), and body position. Design and method: We evaluated the reliability of the oxygen desaturation index (ODI) automatically calculated by the MESAM 4 device in evaluating patients with "complicated" OSAS. These patients present S_{aO_2} drops due to apneas associated with a fall in baseline S_{aO_2} during sleep, as occurs in the "overlap syndrome." Ten patients with complicated OSAS underwent nocturnal MESAM 4 recordings, and we compared the visual and automatic scorings of the ODI. RESULTS: The ODI obtained with visual scoring was significantly higher than ODI automatically calculated by the MESAM 4 in all patients. In some patients, this difference was so significant that it could bias clinical judgment of OSAS severity. We demonstrated that the system did not identify those desaturation events that were superimposed on a fall in baseline S_{aO_2}. The error depends on the algorithm by which the device recognizes the desaturation events and calculates the baseline S_{aO_2}. CONCLUSION: Automatic analysis of MESAM 4 recordings may be misleading in evaluating OSAS patients who have a fall in baseline S_{aO_2} during sleep. In this case, visual scoring performed by a trained polysomnographer is recommended.

Sleep-Related Breathing Disorders in Adolescents Aged 12 to 16 Years: Clinical and Polygraphic Findings—Sanchez-Armengol A, Fuentes-Pradera MA, Capote-Gil F, Garcia-Diaz E, Cano-Gomez S, Carmona-Bernal C, Castillo-Gomez J. Chest 2001;119(5):1393–1400.

Study objectives: To determine the frequency, symptoms, and polygraphic features of sleep-related breathing disorders (SRBD) in adolescents aged 12 to 16 years. DESIGN: Cross-sectional study. SETTING: Randomly selected secondary schools in the city of Seville, SPAIN. PARTICIPANTS: A general population sample of adolescents (n = 101; mean [± SD] age, 13.2 ± 0.8 years). INTERVENTIONS: An 82-item questionnaire regarding anthropometric data and nocturnal and daytime symptoms suggestive of SRBD was administered. Symptoms were evaluated according to a 4-point frequency scale. Snorers answered "sometimes" or "often" in the question about snoring, and nonsnorers answered "never" or "rarely." All subjects underwent an overnight cardiorespiratory polygraphy at home. RESULTS: Twenty-nine percent of the subjects were snorers. Excessive daytime sleepiness was present in 14% of subjects, and sleep apnea was present in 3%. Polygraphy showed a respiratory disturbance index ≥ 10 in 18 subjects (17.8%), but concurrent symptoms highly suggestive of SRBD were found in only 2 subjects (1.9%). Snorers had higher waist-to-hip ratios and a higher frequency of witnessed apnea or labored breathing as well as higher values of respiratory events as compared with nonsnorers. However, oximetry data were similar in both groups. CONCLUSIONS: In a nonselected group of adolescents aged 12 to 16 years, the frequency of symptoms potentially associated with SRBD was similar to that reported for younger children. Snoring was associated with a higher occurrence of other nocturnal symptoms, a more central pattern of body fat distribution, and a higher respiratory disturbance index as compared with nonsnorers. Although polygraphic abnormalities were mild, two cases of probable SRBD were found with a prevalence rate of 1.9%.

Expiratory Flow Limitation and Orthopnea in Massively Obese Subjects—Ferretti A, Giampiccolo P, Cavalli A, Milic-Emili J, Tantucci C. Chest 2001;119(5):1401–1408.

BACKGROUND: Morbidly obese subjects, who often complain about breathlessness when lying down, breathe at low lung volume with a reduced expiratory reserve volume (ERV). Therefore, during tidal breathing the expiratory flow reserve is decreased, promoting expiratory flow limitation (EFL), which is more likely to occur in the supine position, when the relaxation volume of the respiratory system, and hence the functional residual capacity (FRC), decrease because of the gravitational effect of the abdominal contents. PURPOSE: The aim of the study was to assess EFL and orthopnea in massively obese subjects and to evaluate whether orthopnea was associated with the development of supine EFL. METHODS: In 46 healthy obese subjects (18 men) with a mean (± SD) age of 44 ± 11 years and a mean body mass index (BMI) of 51 ± 9 kg/m^2, we assessed EFL in both the seated and the supine positions by the negative expiratory pressure method and assessed postural changes in FRC by measuring the variations in the inspiratory capacity (IC) with recumbency. Simultaneously, dyspnea was evaluated in either position using the Borg scale dyspnea index (BSDI) to determine the presence of orthopnea, which was defined as any increase of the BSDI in the supine position. RESULTS: Partial EFL was detected in 22% and 59%, respectively, of the overall population in seated and supine position. The mean increase in the supine IC amounted to 120 ± 200 mL (4.1 ± 6.4%), indicating a limited decrease in FRC with recumbency in these subjects. Orthopnea, although mild (mean BSDI, 1.7 ± 1.3), was claimed by 20 subjects, and in 15 of them EFL occurred or worsened in the supine position. Orthopnea was associated with lower values of seated ERV ($p < 0.05$) and was marginally related to supine EFL values ($p = 0.07$). No significant effect of age, BMI, obstructive sleep apnea-hypopnea syndrome, FEV_1, and forced expiratory flow at 75% of vital capacity was found on either orthopnea or EFL. CONCLUSION: In morbidly obese subjects, EFL and dyspnea frequently occur with the subject in the supine position, and both supine EFL and low-seated ERV values are related to orthopnea, suggesting that dynamic pulmonary hyperinflation and intrinsic positive end-expiratory pressure may be partly responsible for orthopnea in massively obese subjects.

Risk Factors for Prophylaxis Failure in Patients Receiving Aerosol Pentamidine for *Pneumocystis carinii* Pneumonia Prophylaxis—Wei CC, Gardner S, Rachlis A, Pack LL, Chan CK. Chest 2001;119(5):1427–1433.

OBJECTIVE: The purposes of this study were (1) to determine the incidence of prophylaxis failure in HIV-infected patients receiving aerosol pentamidine (AP) for Pneumocystis carinii pneumonia (PCP) prophylaxis, and (2) to identify risk factors for PCP prophylaxis failure. Setting and design: In Ontario, Canada, AP has been made available for outpatient PCP prophylaxis through a centralized government program, the Ontario Drug Distribution and Monitoring PROGRAM: Data from this administrative observational database were extracted for 2,227 patients who received AP between May 1989 and December 1998. Outcome measurements: The incidence of breakthrough PCP (BPCP) was calculated from the database. A Cox regression model with time-varying covariates was created to examine factors associated with BPCP. The follow-up time was divided into three eras: 1989 to 1991, 1992 to 1994, and 1995 to 1998. These eras were meant to reflect major changes in antiretroviral medication regimens. RESULTS: The overall risk of BPCP was 16.2% over a mean follow-up of 1.67 years. The overall BPCP rate was 9.7/100 patient-years, with rates of 8.8/100, 13.1/100, and 6.3/100

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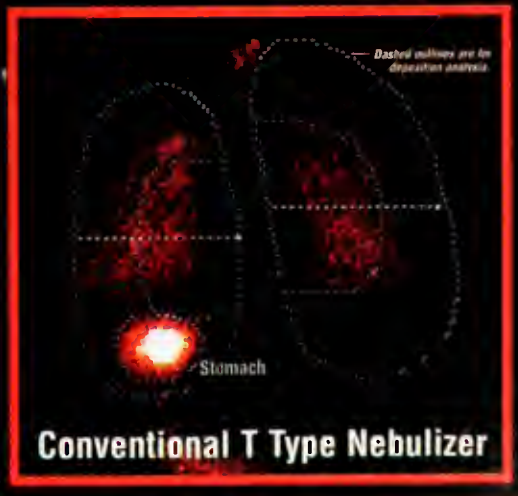

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patient-years in each of the three treatment eras. In the multivariate analysis, significant risk factors for prophylaxis failure were low CD4 count, previous diagnosis of PCP, history of AIDS-defining conditions other than PCP, and antiretroviral treatment era defined above. CONCLUSION: The overall rate of PCP prophylaxis failure has decreased significantly after 1995, coincident with the era of highly active antiretroviral therapies. Initiation of PCP prophylaxis remains necessary in patients with risk factors.

Efficacy of IV Theophylline in Children with Severe Status Asthmaticus—Ream RS, Loftis LL, Albers GM, Becker BA, Lynch RE, Mink RB. Chest 2001;119(5):1480–1488.

Study objective: To determine whether adding IV theophylline to an aggressive regimen of inhaled and IV beta-agonists, inhaled ipratropium, and IV methylprednisolone would enhance the recovery of children with severe status asthmaticus admitted to the pediatric ICU (PICU). DESIGN: A prospective, randomized, controlled trial. Asthma scoring was performed by investigators not involved in treatment decisions and blinded to group assignment. SETTING: The PICU of an urban, university-affiliated, tertiary-care children's hospital. PATIENTS: Children with a diagnosis of status asthmaticus who were admitted to the PICU for ≤ 2 h and who were in severe distress, as indicated by a modified Wood-Downes clinical asthma score (CAS) of ≥ 5. INTERVENTIONS: All subjects initially received continuous albuterol nebulizations; intermittent, inhaled ipratropium; and IV methylprednisolone. The theophylline group was also administered infusions of IV theophylline to achieve serum concentrations of 12 to 17 micrograms/mL. A CAS was tabulated twice daily. Measurements and results: Forty-seven children (median age, 8.3 years; range, 13 months to 17 years) completed the study. Twenty-three children received theophylline. The baseline CASs of both groups were similar and included three subjects receiving mechanical ventilation in each group. All subjects receiving mechanical ventilation and theophylline were intubated before drug infusion. Among the 41 subjects who were not receiving mechanical ventilation, those receiving theophylline achieved a CAS of ≤ 3 sooner than control subjects (18.6 $\pm$ 2.7 h vs 31.1 $\pm$ 4.5 h; $p < 0.05$). Theophylline had no effect on the length of PICU stay or the total incidence of side effects. Subjects receiving theophylline had more emesis ($p < 0.05$), and control patients had more tremor ($p < 0.05$). CONCLUSIONS: Theophylline safely hastened the recovery of children in severe status asthmaticus who were also receiving albuterol, ipratropium, and methylprednisolone. The role of theophylline in the management of asthmatic children in impending respiratory failure should be reexamined.

Predictors of Mortality and Resource Utilization in Cirrhotic Patients Admitted to the Medical ICU—Aggarwal A, Ong JP, Younossi ZM, Nelson DR, Hoffman-Hogg L, Arroliga AC. Chest 2001;119(5):1489–1497.

Background and objective: Cirrhotic patients admitted to the medical ICU (MICU) are associated with high mortality rates and high resource utilization. This study identifies specific predictors of increased mortality and resource utilization and uses them to develop and validate prognostic models in cirrhotic patients admitted to the MICU. METHODS: Cirrhotic patients admitted to the MICU were identified from the Critical Care Section database (January 1993 to October 1998). Clinical data were extracted from chart review including hospital course variables, mortality, and length of stay (LOS). Total cost per case (TCPC) was obtained from the Transition System INC. Multivariate logistic and linear regression analyses identified the independent predictors of increased mortality and resource utilization used for model building (MB) and model validation (MV). RESULTS: A total of 582 cases were randomized to the MB and MV groups. Each group contained 240 cases after exclusion criteria were applied. The MICU mortality rate was 36.6%, and the in-hospital mortality rate was 49.0%. Acute physiology, age, and chronic health evaluation (APACHE) III score (odds ratio [OR], 4.7; 95% confidence interval [CI], 2.70 to 8.16; $p < 0.001$), mechanical ventilation (OR, 4.57; 95% CI, 2.35 to 8.34); $p < 0.001$), and the use of pressors (OR, 7.57; 95% CI, 4.35 to 13.18; $p < 0.001$) were independent predictors of MICU mortality. APACHE III score (OR, 4.96; 95% CI, 2.97 to 8.29; $p < 0.001$), the use of pressors (OR, 6.55; 95% CI, 3.66 to 11.72; $p < 0.001$), and acute renal failure (ARF) (OR, 4.31; 95% CI, 2.41 to 7.71; $p < 0.001$) were independent predictors of in-hospital mortality. Increased LOS in the MICU was associated with mechanical ventilation, ARF, bronchoscopy, bacteremia, use of pressors, transjugular intrahepatic portosystemic shunt (TIPS), and never received cardiopulmonary resuscitation (CPR) ($p < 0.005$). Source of admission, platelet transfusion, bacteremia, pneumonia, and never received CPR were independently associated with increased total LOS ($p < 0.001$). Mechanical ventilation, platelet transfusion, bronchoscopy, TIPS, sepsis, and never received CPR were independent predictors of increased TCPC ($p < 0.001$). CONCLUSION: Simple prognostic models for mortality and resource utilization have been developed for cirrhotic patients admitted to the MICU.

Caregiver Strain Associated with Tracheostomy in Chronic Respiratory Failure—Rossi Ferrario S, Zotti AM, Zaccaria S, Donner CF. Chest 2001;119(5):1498–1502.

Study objectives: The aim of this study was to evaluate the psychological and psychosocial impact of tracheostomy on the caregivers of patients who have undergone tracheostomies. SETTING: Rehabilitation facility. PARTICIPANTS: Sixty-three lay caregivers of inpatients and outpatients with various underlying diseases who have undergone tracheostomies. METHODS: At the beginning of the study, the 63 caregivers completed a previously validated questionnaire designed to assess the problems related to caring for patients with chronic diseases. Approximately 1 year later, 40 of the 63 caregivers completed the same questionnaire a second time. The results were analyzed statistically in order to investigate the caregivers' perceptions of the factors associated with their own particular situation. RESULTS: The answers of the 40 subjects who completed the questionnaire twice revealed the existence of perceived strain persisting over time, which was greater in female caregivers and in those caring for patients who had had a tracheostomy for < 14 months. The younger caregivers (age < 59 years) and those caring for patients receiving nocturnal ventilation expressed a continuing need for information about the disease. Finally, the caregivers said that they, as well as their patients led very restricted personal lives. CONCLUSIONS: Tracheostomy causes a substantial amount of caregiver strain, which should be taken into account when deciding on any treatment plan.

Clinical Correlation with Changing Radiographic Appearance During Partial Liquid Ventilation—Schuster DP, Lange NR, Totuneu A, Wedel M. Chest 2001;119(5):1503–1509.

Study objectives: To evaluate the chest radiographic filling pattern associated with partial liquid ventilation (PLV) with the perfluorochemical perflubron (LiquiVent; Alliance Pharmaceutical Corp; San Diego CA) as a function of dose and timing. DESIGN: Post hoc review of chest radiographs by three independent observers with correlation to clinical variables. SETTING: Phase II randomized, uncontrolled, prospective, multicenter clinical trial. PATIENTS: Sixteen adult patients with diffuse bilateral infiltrates consistent with acute lung injury and a P_{aO_2}/fraction of inspired oxygen (F_{IO_2}) ratio < 300 with positive end-expiratory pressure of 13 cm H_2O and $F_{IO_2} \geq 0.5$. INTERVENTIONS: All patients were treated with either a 10-mL/kg or 20-mL/kg loading dose of perflubron followed by maintenance dosing at 3-h intervals to protocol-determined levels. RESULTS: There was a significant relationship between inhomogeneous radiographic filling during the first 48 h of treatment and the use

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of the lower loading dose of perflubron. Inhomogeneous radiographic filling (in 5 patients) was associated with a lower high-dose/F_{IO_2} ratio at 24 h compared with the remaining patients. These differences resolved by 48 h. There were no other statistically significant correlations identified. CONCLUSIONS: The radiographic appearance of PLV with perflubron appears to depend on the dose administered. Lower doses can be associated with both inhomogeneous radiographic filling and a transient deterioration in oxygenation during the first 24 to 48 h of treatment.

A Telephone-Linked Computer System for COPD Care—Young M, Sparrow D, Gottlieb D, Selim A, Friedman R. Chest 2001;119(5):1565–1575.

The current revolution in communications technology provides an opportunity for novel approaches to management of medical illness. As economic imperatives lead to a progressive reduction in the time that health-care providers spend with their patients, computerized, telephone-linked communication systems offer an inexpensive, widely available alternative with which patients and providers can maintain contact. Such systems may be particularly useful for providing ongoing monitoring and education of patients with chronic illnesses such as COPD. In this article, we describe the general application of telephone-linked communication systems in the health-care setting. We then present in detail one such system, which provides telephone-linked care for COPD (TLC-COPD). The operation of the system is described, as are its theoretical underpinnings in social learning theory. A randomized clinical trial currently is being performed to study the effects of the TLC-COPD system. The rationale for expected improvements in disease control and quality of life, and for a reduction in acute health-care utilization, is discussed.

Iatrogenic Paradoxical Air Embolism in Pulmonary Hypertension—Holcomb BW, Loyd JE, Byrd BF 3rd, Wilsdorf TT, Casey-Cato T, Mason WR, Robbins IM. Chest 2001;119(5):1602–1606.

Paradoxical systemic air embolism (PAE) occurring as a complication of right-to-left intracardiac shunting during evaluation and treatment of pulmonary hypertension (PH) has not been previously reported. We report four cases of PH-associated PAE recently encountered at our center. Two patients with PH experienced transient neurologic deficits during agitated-saline contrast echocardiography (ASCE), and a patent foramen ovale was subsequently diagnosed in both patients. Two patients with Eisenmenger's syndrome (ES), while receiving epoprostenol via multilumen catheters, experienced transient neurologic deficits while flushing the unused port of the catheter. No patient experienced permanent neurologic deficits. We conclude that ASCE poses a risk for PAE in patients with PH and clinically silent, previously undetected, right-to-left intracardiac shunts, and that multilumen catheters used for long-term epoprostenol therapy in ES carry a risk of PAE.

Relationship Between Anxiety, Depression, and Morbidity in Adult Asthma Patients—Rimington LD, Davies DH, Lowe D, Pearson MG. Thorax 2001;56(4):266–271.

BACKGROUND: Symptoms of disease reported by patients reflect the effects of the disease process within the individual and the person's physical and mental ability to tolerate or otherwise cope with the limitations on their functioning. This study examines the relationship between asthma symptoms, disease severity, and psychological status in patients being managed in routine primary healthcare settings. METHODS: One hundred and fourteen subjects from four GP practices, two inner city and two suburban, were studied. Symptoms were assessed by means of the Asthma Quality of Life questionnaire (AQLQ) and a locally devised Q score, and psychological status with the Hospital Anxiety and Depression (HAD) scale. Spirometric values and details of current asthma treatment (BTS asthma guidelines treatment step) were recorded as markers of asthma severity. RESULTS: Symptoms as measured by AQLQ correlated with peak expiratory flow ($r_S = 0.40$) and with BTS guidelines treatment step ($r_S = 0.25$). Similarly, the Q score correlated with peak expiratory flow ($r_S = 0.44$) and with BTS guidelines treatment step ($r_S = 0.42$). Similar levels of correlation of forced expiratory volume in one second (FEV_1) with symptoms were reported. HAD anxiety and depression scores also correlated to a similar extent with these two symptom scores, but there was hardly any correlation with lung function. Logistic regression analysis showed that HAD scores help to explain symptom scores over and above the effects of lung function and BTS guidelines treatment step. Symptoms, depression, and anxiety were higher for inner city patients while little difference was observed in objective measures of asthma. CONCLUSIONS: Asthma guidelines suggest that changing levels of symptoms should be used to monitor the effectiveness of treatment. These data suggest that reported symptoms may be misleading and unreliable because they may reflect non-asthma factors that cannot be expected to respond to changes in asthma treatment.

Bone Mineral Density in Subjects with Mild Asthma Randomised to Treatment with Inhaled Corticosteroids or Non-Corticosteroid Treatment for Two Years—Tattersfield AE, Town GI, Johnell O, Picado C, Aubier M, Braillon P, Karlstrom R. Thorax 2001;56(4):272–278.

BACKGROUND: Inhaled corticosteroids are clearly beneficial for patients with asthma of moderate severity, but the risks and benefits of using them in patients with milder asthma are less clear. We have compared the change in bone mineral density over 2 years in adults with mild asthma randomised to receive an inhaled corticosteroid or non-corticosteroid treatment. METHODS: Subjects with mild asthma (mean forced expiratory volume in one second (FEV_1) 86% predicted, mean age 35 years, taking β agonists only) were randomised to receive inhaled budesonide, inhaled beclomethasone dipropionate, or non-corticosteroid treatment for 2 years in a prospective randomised open study in 19 centres in France, New Zealand, Spain, and the UK. The corticosteroid dose was adjusted according to a written self-management plan. The main outcome measure-change in bone mineral density after 6, 12, and 24 months-was measured "blind." Secondary outcomes included lung function, the relation between change in bone density and inhaled steroid dose and change in biochemical markers of bone metabolism. RESULTS: Of 374 subjects randomised, 239 (64%) completed the study and were included in the analysis. The median daily doses of inhaled budesonide (n=87) and beclomethasone (n=74) were 389 μg and 499 μg, respectively. Subjects treated with an inhaled corticosteroid had better asthma control than those in the reference group (n=78). Change in bone mineral density did not differ between the three groups over the 2 years, nor did it correlate with changes in markers of bone metabolism. The mean change in bone mineral density over 2 years in the budesonide, beclomethasone dipropionate, and reference groups was 0.1%, -0.4%, and 0.4% for the lumbar spine and -0.9%, -0.9%, and -0.4% for neck of the femur. Mean daily dose of inhaled steroid was related to reduction in bone mineral density at the lumbar spine but not at the femoral neck. CONCLUSION: In subjects with mild asthma an inhaled corticosteroid provided better asthma control than alternative non-corticosteroid treatment with no difference in change in bone mineral density over 2 years. The relation between dose of inhaled corticosteroid and change in bone density at the lumbar spine may be due to a direct effect of inhaled corticosteroids on bone. Since inhaled steroid dose is also related inversely to lung function, an effect of asthma severity on bone density was also possible.

Adverse Effects of Oral Corticosteroids in Relation to Dose in Patients with Lung Disease— Walsh LJ, Wong CA, Oborne J, Cooper S,

Lewis SA, Pringle M, Hubbard R, Tattersfield AE. Thorax 2001;56(4): 279–284.

BACKGROUND: The adverse effects of oral corticosteroids are widely recognised but there are few quantitative data on which to base advice to patients. In a two part cross sectional study we compared adverse effects in patients with lung disease taking oral corticosteroids and control subjects and related the adverse effects to corticosteroid dose in the patient group. METHODS: Data on oral corticosteroid use, lifestyle, fractures, and other possible adverse effects were collected by questionnaire and compared between a community based cohort of patients taking continuous or frequent intermittent oral corticosteroids for asthma, chronic obstructive pulmonary disease, or alveolitis and age and sex matched control subjects. Dose related effects were explored in the corticosteroid group using cumulative dose quartiles and multiple logistic regression. RESULTS: A total of 367 patients (≥ 50 years, 48% female) and 734 control subjects completed the questionnaire. The cumulative incidence of fractures since the time of diagnosis was 23% for patients taking oral corticosteroids and 15% in the control group (odds ratio (OR) 1.8; 95% confidence interval (CI) 1.3 to 2.6). Patients were more likely to have had a fracture of the vertebrae (OR 10; 95% CI 2.9 to 34), hip (OR 6; 95% CI 1.2 to 30), and ribs or sternum (OR 3.2, 95% CI 1.6 to 6.6) than control subjects. They also reported a significant increase in cataracts, use of antacids, muscle weakness, back pain, bruising, oral candidiasis, and having fewer teeth. The effects of oral corticosteroids were dose related: the odds ratio for patients in the highest compared with the lowest cumulative dose quartile (median prednisolone dose 61 g versus 5 g) ranged from 2 for all fractures to 9 for vertebral fractures and bruising. CONCLUSIONS: By quantifying the morbidity associated with the use of oral corticosteroids, this study should help to rationalise their long term use.

Sputum Induction As a Research Tool for Sampling the Airways of Subjects with Cystic Fibrosis—Henig NR, Tonelli MR, Pier MV, Burns JL, Aitken ML. Thorax 2001;56(4):306–311.

BACKGROUND: Sputum induction (SI) has proved to be a reliable non-invasive tool for sampling inflammatory airway contents in asthma, with distinct advantages over collection of expectorated sputum (ES) and bronchoalveolar lavage (BAL). A study was undertaken to evaluate the safety of SI and to assess if it might be an equally valuable outcome tool in patients with cystic fibrosis (CF). METHODS: The safety of the procedure was examined and sample volume, cell counts, cytokine concentrations, and bacterial culture results obtained by SI, spontaneous ES, and fibreoptic bronchoscopy were compared in 10 adults with CF. RESULTS: SI was well tolerated and was preferred to BAL by all subjects. The mean (SE) sample volume obtained by SI was significantly greater than ES (6.74 (1.46) mL v 1.85 (0.33) mL, p = 0.005). There was no significant difference in the number of cells per mL of sample collected. There was a difference in the mean (SD) percentage of non-epithelial, non-squamous cells collected (67 (28)%, 86 (21)%, and 99 (1)% for ES, SI, and BAL, respectively). These percentage counts were different between ES and both SI and BAL (p=0.03 and p=0.006, respectively). Cell differential counts (excluding squamous cells) from all collection methods were similar (mean (SD) 84 (9)%, 87 (7)%, and 88 (11)% polymorphonuclear cells for ES, SI, and BAL, respectively). The concentrations of interleukin (IL)-8 and tumour necrosis factor (TNF)-α were the same in all three samples when corrected for dilution using urea concentration. The test specific detection rate for recovery of bacteriological pathogens was 79% for SI, 76% for ES, and 73% for BAL. CONCLUSION: SI offers safety advantages over BAL and may be a more representative airway outcome measurement in patients with CF.

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Unintended Consequences of Artificial Airways: Replacement Parts Are Never As Good as the Factory-Installed

In the early part of the 19th century a Frenchman named Desault provided the first modern description of peroral tracheal intubation. Truth be told, he was part of the great tradition of innovators who took advantage of what appeared to be an adverse event and made it into something positive. Desault was actually trying to place a feeding tube, and when he poured some bullion down the tube he discovered that he had intubated the trachea rather than the esophagus.[1,2] It seems fitting that modern intubation started with a complication, since the history of oral intubation is filled with adverse events related to this lifesaving modality of treatment.

In this issue of Respiratory Care, Siobal et al report an unfortunate case of a young burn victim who suffered a massive fatal hemorrhage from a tracheo-innominate artery fistula.[3] The authors make a convincing case that the hemorrhage resulted from direct tracheal erosion by the tip of the endotracheal tube. Showing remarkable determination to explain this rarely reported complication, the authors carefully performed a laboratory study in which they determined that the force exerted by the tip of the endotracheal tube used in their patient substantially exceeded the force exerted by a variety of other tubes. Though the authors concluded that this probably was a contributory factor, they appropriately reeognize that such an event is multifactorial. I agree with them.

See The Case Report on Page 1012

The fault lies not in our tubes but in ourselves (the human body). We are far too complicated to be easily replaced by new parts, and the airway is no exeeption. The upper airway performs a multitude of functions. The simplest, and the one that an endotracheal tube replaces, is that of a conduit from the lower respiratory tract to the atmosphere. Other important functions include humidification, filtration, immune response, removal of debris, deglutition, expectoration, and speech. The artificial conduit we place not only interferes with these functions, but tends actually to be destructive of the surrounding tissues and organs.

The fundamental problem that is common to all endotracheal tubes is that they must have some rigidity in order to be effective conduits that do not kink or collapse. Given this rigidity, there will be some force applied to the mucosa of the mouth, pharynx, larynx, and trachea. The smaller the area of eontact, the higher the pressure, since pressure is directly proportional to force and inversely proportional to the area over which that force is applied. In studies of the pressures exerted by endotracheal tubes in the larynx, Weymuller et al found that at the points of contact with the mucosa overlying the cricoid and arytenoid eartilages, endotracheal tubes routinely exert pressures far in excess of the mucosal perfusion pressure of approximately 30 mm Hg.[4] Endotracheal tubes routinely result in ischemic areas of the laryngeal mucosa and this ischemia routinely results in ulceration within days.[5] In the case reported by Siobal et al, the tip of the tube remained in constant contact with the mucosa for a prolonged period in a nutritionally deprived patient, and the result was a fatal outcome.[3] Would a less rigid tip have prevented such an outcome? I am not convinced that is the ease, nor do I know whether a tube could be engineered to provide the speeial suction port described while being any less rigid.

Attempts have been made to engineer different types of tubes to minimize pressures. The late B Raymond Fink, an anesthesiologist interested in the larynx, suggested that a pentagonal conformation would spread the force over a larger area (personal communication, Raymond Fink, 1982) but such a tube was never constructed, in part because of our data suggesting that the pressures would still exceed mucosal perfusion pressure. Kolobow et al in 1994 published a description of an ultra-thin-walled tube with gills in place of a cuff that was designed to produce less mucosal pressure.[6] This elever design seemed like it might solve some problems by producing less pressure while producing a seal and allowing tube movement. As far as I know, such a tube has never been produced commercially, perhaps because it would be very costly. In any case, the problem of producing a satisfactory replacement for the human airway that does not lead to tissue destruction still seems to be a difficult problem.

Would a tracheotomy have helped? Tracheo-innominate artery fistulas are a much more common complication of tracheotomy than of endotracheal intubation. Needless to say, tracheotomies have their own set of complications, especially in burn patients.

What is the likelihood of improved devices? First of all, as I have argued above, there may be some serious limitations that will keep any device from sparing the mucosa of the airway. Second, research in this area will probably continue to be limited, for several reasons. Endotracheal tubes are relatively inexpensive devices, generally costing only a few dollars. Even specialty tubes are not terribly expensive compared to even a day's medication for a critically ill patient. Hence, the potential benefit to a manufacturer is limited. Studies of safety and efficacy are not required for introducing a new endotracheal tube, since these are considered medical devices and are based on an existing concept, thus eliminating another reason for research.

In the absence of a series or a study, the interesting case report by Siobal et al remains an isolated incident in a patient with an unfortunate congruence of risk factors. The patient had a high likelihood of dying even without the endotracheal tube complication. The authors decided not to use that particular tube in the future and not to keep tubes fixed in location for long periods. Their decisions are understandable and may limit such an occurrence in the future, but given that we are making dramatic interventions in critically ill patients, we will undoubtedly continue to see a certain incidence of unexpected morbid and mortal events.

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Tracheal-Innominate Artery Fistula Caused by the Endotracheal Tube Tip: Case Report and Investigation of a Fatal Complication of Prolonged Intubation

Mark Siobal RRT, Richard H Kallet RRT, Roger Kraemer CRT, Emmanuel Jonson CRT, Donald Lemons CRT, David Young MD, Andre R Campbell MD, William Schecter MD, and Julin Tang MD

CASE REPORT: A patient with extensive burns was intubated with an 8.0 mm internal diameter endotracheal tube (ETT) equipped with a subglottic suction port (Mallinckrodt HiLo Evac). The ETT was secured to a left upper molar with wire sutures throughout the hospitalization course to ensure airway stability. On the 40th day of intubation, the patient exsanguinated and died from a tracheo-innominate artery fistula. Postmortem examination revealed a 1 cm lesion of the left anterior tracheal wall at the position of the ETT tip. The prolonged stationary position of the ETT was considered the primary factor responsible for the fistula. Yet tracheo-innominate artery fistula normally is associated with high cuff pressures rather than with the tube tip. The special ETT construction required for the subglottic suction feature was suspected to have increased tube rigidity and may have played a contributory role. METHODS: The rigidity of the Mallinckrodt HiLo Evac was measured with a mechanical model and compared to 5 other commercially-available ETTs. Rigidity was expressed as the force generated by the ETT tip when the tube curvature was altered by 5 cm and 10 cm of flexion from its resting position. RESULTS: The mean force exerted by the Mallinckrodt HiLo Evac was 10.1 ± 2.8 g at 5 cm of flexion and 17.7 ± 5.1 g at 10 cm of flexion. This was significantly greater than all other ETT brands tested (by one-way analysis of variance and Student-Newman-Kuels test, $p < 0.05$). CONCLUSION: This case of fatal tracheo-innominate artery fistula formation associated with an ETT tip was unusual because of the extended duration of endotracheal intubation and the complexity of the patient's airway management problems. Our data suggest that the higher rigidity of the HiLo Evac ETT may have contributed to fistula development at the tube tip. However, we do not believe that the higher rigidity of the HiLo Evac ETT necessarily poses any greater risk than other ETTs under normal circumstances, in which the tube tip is not fixed in a stationary position for an extended period. *Key words: tracheo-innominate artery fistula, endotracheal tube, intubation, Mallinckrodt HiLo Evac, tracheal erosion, tracheal trauma, mucosal trauma, subglottic suction, suction catheter.* [Respir Care 2001;46(10):1012–1018]

Introduction

Evacuation of pooled secretions from the subglottic space above the endotracheal tube (ETT) cuff is a strategy to help prevent ventilator-associated pneumonia.[1] Removing oropharyngeal secretions from the subglottic area is thought to reduce occult aspiration of secretions containing high bacterial loads. The HiLo Evac ETT (Mallinckrodt, St Louis, Missouri) incorporates a suction port above the

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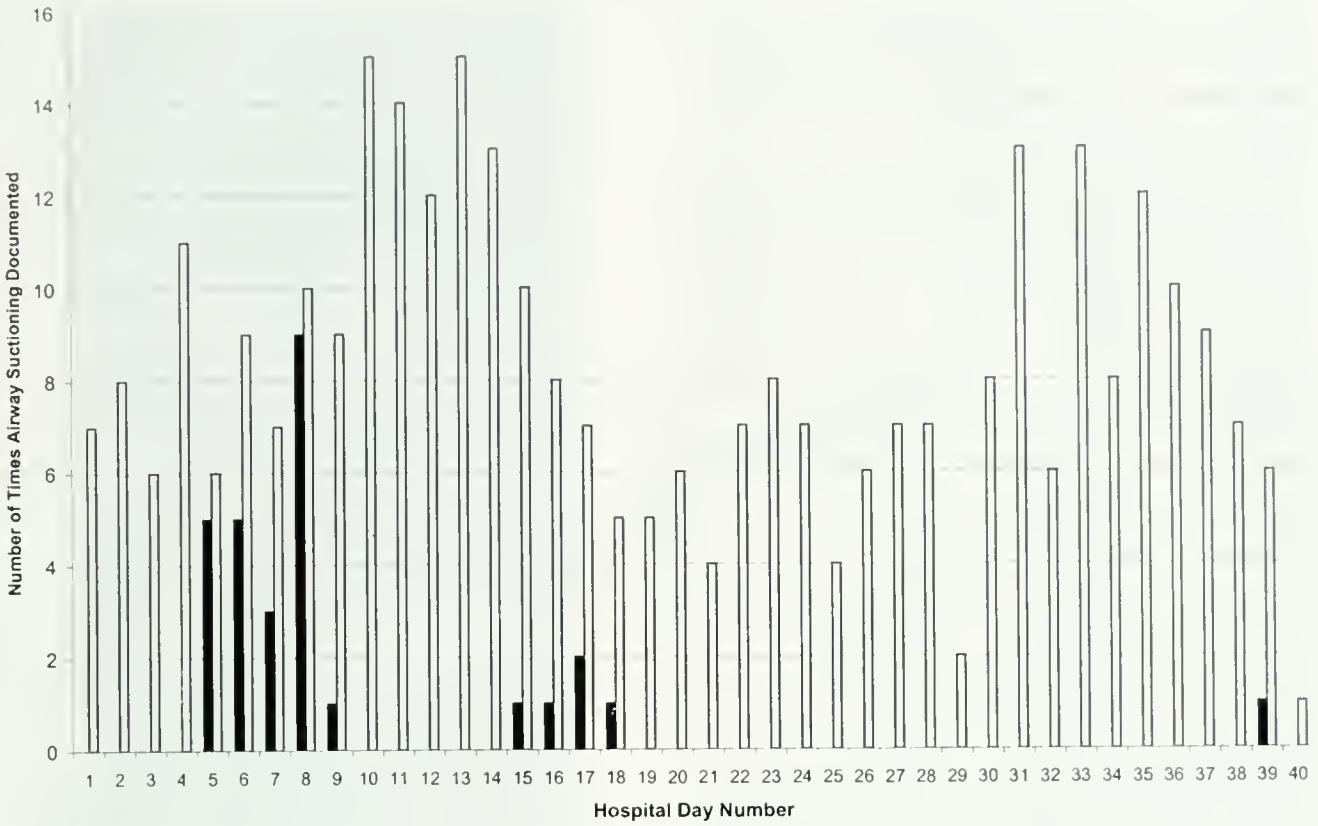

Fig. 1. Episodes of bloody tracheal aspirate during the patient's hospitalization. The clear bars represent the number of documented airway suctionings performed each hospital day. The black bars represent the number of times bloody aspirate was noted during those suctionings.

dorsal aspect of the cuff that enables secretion removal from the subglottic space. Compared to a standard ETT, the HiLo Evac ETT has been shown to reduce the incidence of ventilator-associated pneumonia by 40–50%, delay its onset,[2–4] and potentially reduce costs.[5] Use of the HiLo Evac ETT was implemented at our institution to examine its impact on ventilator-associated pneumonia rates.

See the Related Editorial on Page 1010

Tracheal injury secondary to intubation has been well documented.[6–8] Predisposing factors affecting tracheal mucosal integrity include thermal inhalation injury,[9,10] infection,[7] ischemia secondary to hypotension,[7,10–12] and compromised nutritional status.[11] Tracheal-innominate artery erosion is rare, with an incidence rate of 0.6–0.7%,[13] and is almost exclusively associated with tracheostomy.[14] With tracheostomy tubes, lesion sites have been associated with both the cuff and the tube tip.[13,15] Tracheo-innominate artery fistula requires emergency surgical intervention, and the mortality rate from the condition is high.[13] To our knowledge, we are reporting the second case of a fatal tracheal-arterial erosion caused by an ETT[11] and the first report of this complication at the site of the ETT tip.

Case Summary

A 19-year-old male suffered 2nd and 3rd degree burns to 70% of his body surface area, including the face, neck, torso, and extremities. On admission to the emergency department, the patient was electively intubated with an 8.0 mm internal diameter HiLo Evac ETT, which was secured with tape. The ETT position was verified by chest radiograph. The patient was transported immediately to the operating room for burn wound debridement. A bronchoscopy was performed, which revealed mild proximal airway inflammation. The ETT was anchored to a left upper molar with wire sutures in the operating room to ensure airway stability because of the extensive neck and facial burns. The ETT remained in a fixed position, with the tube tip at the level between the 2nd and 3rd thoracic vertebrae, approximately 4 cm above the carina on chest radiograph, throughout the course of hospitalization. Low continuous suction (vacuum pressure of 20 mm Hg) was

applied to the port located at the dorsal curvature above the ETT cuff, to evacuate pooled secretions in the subglottic space, per the manufacturer's recommendations. Cuff pressure was regulated automatically using a commercially available device (PressureEasy, IPI Medical Products, Chicago, Illinois).

Throughout hospitalization, the patient's cardiovascular status was stable (systolic blood pressure $\geq$ 100 mm Hg). The patient developed sepsis, with blood, wound, and tracheal aspirate cultures that were positive for *Proteus mirabilis*, *Candida albicans*, and *Moraxella catarrhalis*, for which he was treated with a regimen of tobramycin, fluconazole, and ciprofloxacin, respectively. Indirect calorimetry revealed extremely high caloric requirements, between 3,900 and 4,600 kcal/d, which were difficult to meet with nutritional support, because of further risk of wound contamination and sepsis from watery stools.

During the course of hospitalization, the patient's pulmonary status was notable for hemoptysis and acute respiratory distress syndrome. Bloody tracheal aspirates were noted by the 5th day of hospitalization and were documented over the next 4 consecutive days. The frequency and magnitude of hemoptysis declined thereafter, and did not recur between the 19th and 39th days of hospitalization (Fig. 1). On the 10th day after injury, the patient met the North American-European Consensus criteria for acute respiratory distress syndrome.[16] By the 26th day, the suction port connector of the ETT broke, and continuous low vacuum pressure (20 mm Hg) applied to the subglottic space was discontinued.

On the 40th day of hospitalization, the patient developed acute pulmonary hemorrhage. Because of a suspected cuff failure (due to the simultaneous development of a large air-leak around the ETT), the patient was reintubated, at which time pulsatile bleeding through the vocal cords was noted. Attempts to tamponade the bleeding with the second ETT cuff were unsuccessful. Effective ventilation could not be achieved, despite suctioning a large volume of blood from the patient's lungs. The patient deteriorated into shock, with episodes of asystole, and was treated with 2 units of packed red blood cells, large volume crystalloid resuscitation, and several boluses of epinephrine. He suffered cardiac arrest, and cardiopulmonary resuscitation was instituted without success.

Postmortem exam revealed a 1 cm lesion of the left anterior tracheal wall below the level of the cuff (Fig. 2). Tracheal wall erosion and fistula formation into the innominate artery was evident at the approximate position of the ETT tip (4 cm above the carina on chest radiograph). Use of the HiLo Evac ETT was temporarily discontinued at our institution over concern that the device may have contributed to the patient's tracheal lesion and death. The incident was reported to the manufacturer and by MedWatch report to the United States Food and Drug Administration.

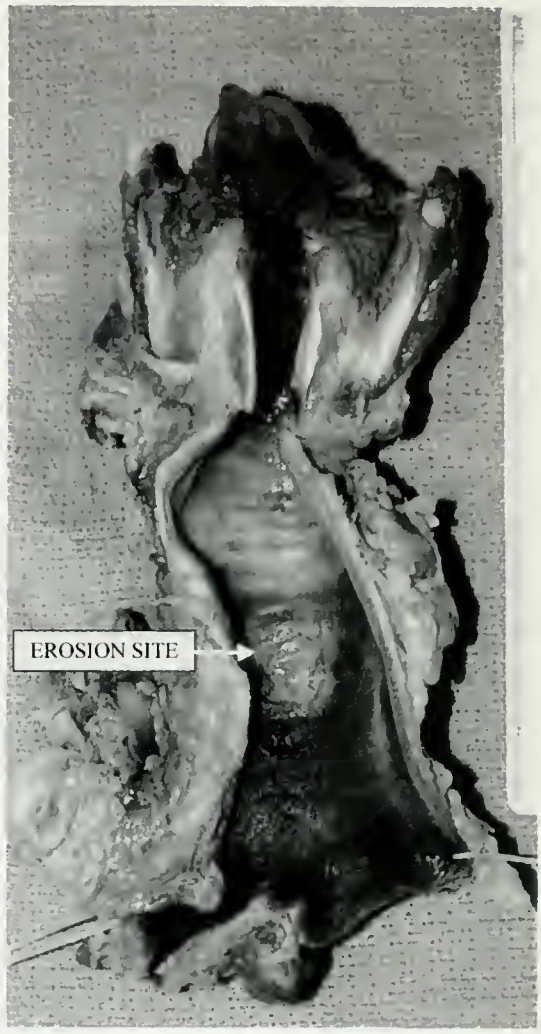

Fig. 2. Excised segment of the patient's trachea at post-mortem examination, showing the erosion site approximately 4 cm above the carina. Area above the lesion shows the approximate position of the ETT cuff.

An internal review of the incident identified 2 factors that may have contributed to tracheal erosion. First, the method of securing the ETT in one position for 40 days directed the tip of the tube to impact against a focal area of the anterior tracheal wall. Direct pressure caused by the ETT tip, in conjunction with repetitive tracheal mucosal trauma from the insertion of suction catheters, was believed to be the main factor contributing to the tracheal wall erosion and arterial fistula formation. Second, tracheo-innominate artery fistula is normally associated with high cuff pressures rather than with the tube tip. The special ETT construction required for the subglottic suction feature may have increased tube rigidity and therefore was suspected to have contributed to fistula development. The incorporation of an additional suction lumen in the HiLo

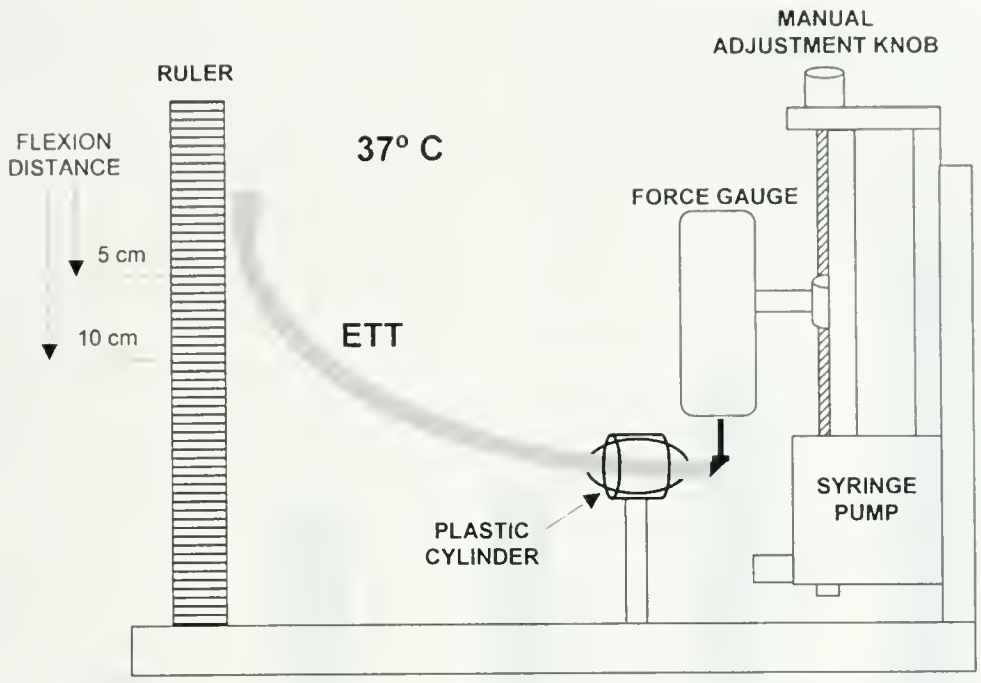

Fig. 3. Modified mechanical model of Benumof et al[17] designed to test endotracheal tube (ETT) rigidity.

Evac ETT increased the overall tube diameter by 0.7 to 0.8 mm more than a standard ETT of the same internal diameter made by the same manufacturer (per manufacturer's specifications). This difference in ETT wall thickness, in addition to the fact that the HiLo Evac ETT is manufactured without a Murphy eye, may have contributed to the rigidity of the tube tip.

Methods

To determine if the greater tube thickness and the absence of a Murphy eye contributed to tip rigidity, a laboratory experiment was conducted to quantify differences in overall tube stiffness. A mechanical model and technique described by Benumof et al[17] was used to measure the force generated at the tip of the HiLo Evac and comparable ETTs of the same internal diameter, while changing the degree of tube flexion (Fig. 3). A laboratory stand was configured to hold the ETT while the cuff was inflated inside a 3 cm long plastic cylinder with an internal diameter of 22 mm. A digital force gauge (FGE-1, Shimpo Instruments, Itasca, Illinois) was attached to a modified syringe pump equipped with a manual adjustment knob (Cobe Laboratories, Lakewood, Colorado) and mounted to the stand. A ruler was secured at the other end and adjusted to measure the distance of tube flexion.

The ETT cuff was centered in the plastic cylinder. A cuff pressure of 50 cm H_2O was used to ensure tube stability during the measurements and to prevent contact of the tube lumen internal to the cuff with the plastic cylinder walls during flexion (see Fig. 3).

The natural curvature of the ETT was centered in the vertical plane, perpendicular to the horizontal plane dissecting the center of the ETT cuff. Force gauge calibration and accuracy were verified using precision weights of 1, 10, and 50 g. The force meter was positioned to make contact with the ETT tip using the manual adjustment knob and adjusted so that a minimum force of 0.1–0.3 g was detected. The ETT end was then flexed downward a distance of 5 cm from its resting position and secured in place. Two minutes were allowed for the tube to conform to its new shape in the flexed position, and the force generated at the tip was recorded. The ETT was then flexed to a distance of 10 cm from its resting position and the measurement was repeated.

Measurements were performed on 6 types of ETTs from 5 manufacturers: Mallinckrodt HiLo Evac, Mallinckrodt Standard, Portex (SIMS Portex, Keene, New Hampshire), Sheridan (Kendall Company, Mansfield, Massachusetts), Rusch (Rusch Inc, Duluth, Georgia), and Polamedco (Polamedco, Marina del Rey, California). To determine whether the suspected rigidity was an inherent characteristic of the HiLo Evac ETT, rigidity was measured in 4 tube sizes: 6.0, 7.0, 7.5, and 8.0 mm internal diameter. A single measurement was made from 4 individual tubes from the same lot number in each size, so that a total of 16 ETTs were tested from each manufacturer. All tubes were preheated for at least 1 hour, to an environmental temperature of 37

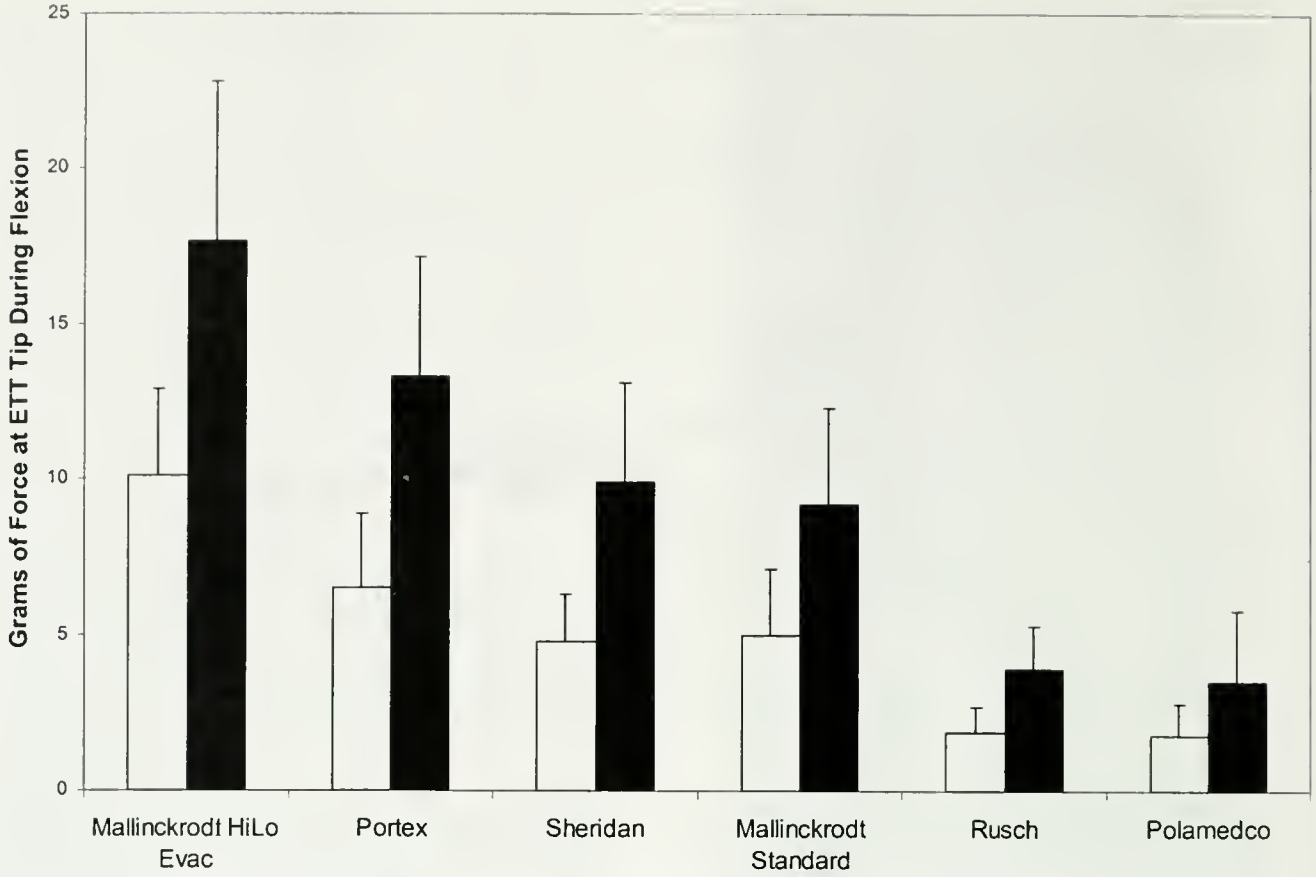

Fig. 4. Endotracheal tube (ETT) rigidity measured as force in grams at 2 levels of tube flexion, among 6 varieties of endotracheal tube. Clear bars represent force measurements at 5 cm of flexion. Black bars represent force measurements at 10 cm of flexion.

C, and measurements were performed at this temperature inside an isolette (Air-Shields/Hill-Rom, Batesville, Indiana). The results were expressed as the force generated at 5 cm and 10 cm of flexion minus the initial force (0.1–0.3 g). Values are reported as mean ± standard deviation. Differences in values were analyzed by one-way analysis of variance and the Student-Newman-Kuels test.[18] Results were considered significant if $p < 0.05$.

Results

At both 5 cm and 10 cm of flexion, the HiLo Evac ETT exerted significantly more force than all other ETTs tested (Fig. 4). The higher rigidity of the HiLo Evac ETT was apparent in all sizes of ETT tested.

The mean force exerted by the HiLo Evac ETT was 10.1 ± 2.8 g at 5 cm of flexion and 17.7 ± 5.1 g at 10 cm of flexion. In contrast, the aggregate mean force exerted by all other ETTs combined was 4.0 ± 1.6 g at 5 cm flexion and 8.0 ± 2.8 g at 10 cm of flexion (Table 1).

Discussion

We have described an unfortunate incident of death following innominate artery fistula formation secondary to tracheal erosion in a complex case of severe, extensive body surface burns, sepsis, and acute respiratory distress syndrome. The patient presented 5 airway management problems. First, his airway patency was tenuous because of thermal airway injury and edema formation from aggressive fluid resuscitation. Second, his ETT could not be secured easily by normal methods because of extensive neck and facial burns. Third, the patient required frequent position changes and multiple transports to the operating room for wound care, both of which increased the probability of accidental extubation. Therefore, the ETT was secured into place with wire sutures for maximum security. This presented the fourth problem: the ETT position could not be routinely adjusted, so the tube remained in one position for an extended period. Therefore, direct pressure caused by the ETT tip (in conjunction with repetitive tracheal mucosa trauma from the insertion of suction cath-

Table 1 Grams of Force at Endotracheal Tube Tip Measured During Flexion

Size	Manufacturer	5 cm Flexion (g)	10 cm Flexion (g)
6.0*	Mallinckrodt HiLo Evac	9.2 ± 1.5	14.7 ± 1.1
	Portex	4.2 ± 0.7	9.7 ± 1.3
	Sheridan	3.0 ± 0.6	6.0 ± 1.0
	Mallinckrodt Standard	3.1 ± 1.0	6.2 ± 1.8
	Rusch	1.6 ± 0.3	3.1 ± 0.9
	Polamedco	1.1 ± 0.4	1.8 ± 0.6
7.0*	Mallinckrodt HiLo Evac	10.8 ± 4.1	18.3 ± 6.5
	Portex	4.9 ± 0.7	10.2 ± 1.6
	Sheridan	5.2 ± 1.0	10.9 ± 2.9
	Mallinckrodt Standard	4.9 ± 1.6	8.7 ± 1.1
	Rusch	1.1 ± 0.4	2.7 ± 0.8
	Polamedco	1.3 ± 0.5	2.1 ± 0.3
7.5*	Mallinckrodt HiLo Evac	10.4 ± 1.6	19.5 ± 5.2
	Portex	7.4 ± 1.4	15.3 ± 2.7
	Sheridan	4.5 ± 0.4	9.9 ± 2.1
	Mallinckrodt Standard	5.2 ± 1.5	10.2 ± 1.6
	Rusch	2.5 ± 0.8	5.2 ± 1.6
	Polamedco	2.0 ± 0.6	4.1 ± 1.1
8.0*	Mallinckrodt HiLo Evac	10.0 ± 4.1	18.3 ± 6.6
	Portex	9.6 ± 0.6	18.0 ± 1.5
	Sheridan	6.7 ± 0.8	13.0 ± 2.0
	Mallinckrodt Standard	6.7 ± 2.8	11.8 ± 4.2
	Rusch	2.4 ± 0.5	4.4 ± 0.8
	Polamedco	2.9 ± 1.0	6.2 ± 2.7
Aggregate data (all sizes†)	Mallinckrodt HiLo Evac	10.1 ± 2.8‡	17.7 ± 5.1‡
	Portex	6.5 ± 2.4	13.3 ± 3.9
	Sheridan	4.8 ± 1.5	9.9 ± 3.2
	Mallinckrodt Standard	5.0 ± 2.1	9.2 ± 3.1
	Rusch	1.9 ± 0.8	3.9 ± 1.4
	Polamedco	1.8 ± 1.0	3.5 ± 2.3

Values are mean ± SD
*n = 4 for each manufacturer
†n = 16 for each manufacturer
‡$p < 0.05$ compared to aggregate data from all other brands.

eters) was probably the main factor contributing to the tracheal wall erosion and arterial fistula formation. However, we have used this method to secure ETTs in severe burn cases for many years without complication. Fifth, severe circumferential burns and edema around the face and neck precluded tracheostomy.

Tracheo-arterial fistula formation resulting from an ETT is extremely rare. In the only known previous report,[11] extensive vascular injuries in the area of the erosion was thought to have been a predisposing factor. In our case, postmortem examination revealed that the tracheo-arterial injury occurred at the ETT tip, and not the level of the cuff. Our laboratory investigation found that the HiLo Evac ETT exerted more force at its tip than any other tube that was tested. However, there is no evidence in the scientific literature quantifying what level of force exertion is clinically relevant. The intent of the experimental model was to perform a simple mechanical measurement to quantify differences in tube rigidity. Interpretation of the clinical implications of these data are limited and they may have little relevance in vivo, where pressure exerted by the ETT occurs at multiple sites. Furthermore, it is impossible to know whether the differences we found in tube rigidity (after heating to body temperature for an hour) would still exist in vivo after several days or weeks of intubation.

We wish to emphasize that the HiLo Evac ETT has been studied in hundreds of patients and used in thousands more worldwide. We are unaware of any reported serious complications with use of this tube under normal critical care conditions. Our report describes an extremely difficult case of airway management. In patients requiring long-term intubation and in whom normal ETT repositioning cannot be done, it may be prudent to avoid using the more rigid HiLo Evac tube.

Other factors may have contributed to the tracheal-innominate artery erosion. These include the initial thermal injury to the tracheal mucosa, sepsis, the ongoing inability to meet the large nutritional demands of the patient (because it would adversely affect tissue healing), and repetitive tracheal trauma from suction catheters.

Tracheal trauma related to suction catheters has been documented in animal studies,[19] in humans at autopsy,[8] and during radiographic follow-up after intubation.[20] Passing suction catheters through an ETT tip fixed at a constant position would repeatedly cause the catheter to impact and deflect off the tracheal wall at a focal site and result in mucosal trauma and ulceration.

Conclusion

In conclusion, we have reported the second known case of death from tracheo-arterial fistula during endotracheal intubation and the first case in which evidence directly implicated the ETT tip. Inability to change the ETT position for an extended period (40 d) was believed to be the primary cause. We speculate that the greater rigidity of the HiLo Evac ETT may have played a contributory role. Therefore, as a precaution, it may be prudent to avoid using the HiLo Evac ETT under similar circumstances of unusual airway management problems.

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Airway Pressure Release Ventilation with a Short Release Time in a Child with Acute Respiratory Distress Syndrome

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Airway pressure release ventilation (APRV) allows ventilation and oxygenation to occur at lower peak and mean airway pressures than conventional positive pressure ventilation. The use of APRV in adults is an effective method of ventilation for patients with acute lung injury and acute respiratory distress syndrome. However, the use of APRV in children is less established. We report the use of APRV with a short release time of 0.2 s in a child with acute respiratory distress syndrome secondary to respiratory syncytial virus pneumonia. *Key words: airway pressure release ventilation, acute respiratory distress syndrome, respiratory syncytial virus.* [Respir Care 2001;46(10):1019–1023]

Introduction

The treatment strategy in acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) is to maintain oxygenation and provide ventilation while the patient's lungs recover from the initial insult. The mainstay of this support is invasive ventilation, either conventional positive pressure ventilation (PPV) or nonconventional ventilation such as high-frequency oscillatory ventilation or inverse ratio ventilation. Some patients even require further support with extra-corporeal membrane oxygenation. The respiratory support provided for ARDS patients can lead to complications such as oxygen toxicity and barotrauma. Furthermore, nonconventional methods of ventilation often require heavy sedation and neuromuscular blockade, which can further complicate a patient's course in the intensive care unit.

In airway pressure release ventilation (APRV), ventilation is provided by a release in airway pressure, coupled with the patient's spontaneous breathing. Since the patient is able to breathe spontaneously throughout the entire respiratory cycle with this mode of ventilation, the need for heavy sedation and neuromuscular blockade is less than with other methods of nonconventional ventilation. Because APRV allows lower airway pressures while providing adequate oxygenation, the incidence of barotrauma may also be decreased. Hence, APRV offers a possible advantageous alternative to other modes of nonconventional ventilation.

Success with APRV in adults has been reported, but the pediatric experience consists of only a few case reports and abstracts, with the shortest release time being 1.9 s. We present a case of severe respiratory distress that was refractory to conventional PPV but that responded to APRV.

Case Summary

The patient was a 2½-year-old, 17 kg boy with developmental delay. He was transferred from a pediatric nursing care facility to our pediatric intensive care unit because of progressive dyspnea, fever of 39.0° C, and cough. His medical history was notable for mental retardation, cerebral palsy, epilepsy, and hydrocephalus with a ventriculoperitoneal shunt secondary to intraventricular hemorrhage. He had also had a fundoplication with feeding gastrostomy tube, hypothyroidism, and asthma. Three days prior to his admission, the child was started on oxygen because of his dyspnea. A chest radiograph obtained on the day prior to his admission showed left lower lobe pneumonia with effusion. The patient was treated with amoxicillin-clavulanate and oral furosemide. The referring hospital also began the child on albuterol aerosol therapy and oral prednisone at 2 mg/kg/d.

On admission to the pediatric intensive care unit, his vital signs were notable for a temperature of 38.1° C, heart

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Table 1. Summary of Ventilator Settings and Blood Gas Values Before APRV

Time	Mode	F_{IO_2}	V_T/PIP (mL/cm H_2O)	PS (cm H_2O)	PEEP (cm H_2O)	f (breaths/min)	Type	pH	P_{aCO_2} (mm Hg)	P_{aO_2} (mm Hg)
Admission	NREM	1.0	—	—	—	—	ABG	7.47	43	122
8 hours	VC	1.0	170	13	5	20	VBG	7.47	37	39
24 hours	VC	0.5	115	8	6	20	VBG	7.38	50	97
120 hours	PC	1.0	36	15	10	20	ABG	7.31	70	85

APRV = airway pressure release ventilation
F_{IO_2} = fraction of inspired oxygen
VT = tidal volume
PIP = peak inspiratory pressure
PS = pressure support
PEEP = positive end-expiratory pressure
f = respiratory rate
P_{aCO_2} = arterial partial pressure of carbon dioxide
P_{aO_2} = arterial partial pressure of oxygen
NREM = non-rebreathing face mask
ABG = arterial blood gas
VC = volume control
VBG = venous blood gas
PC = pressure control

rate of 70 beats/min, blood pressure of 115/46 mm Hg, respiratory rate of 64 breaths/min, and oxygen saturation of 100% on 100% oxygen at 8 L/min by nonrebreather face mask. Physical examination on admission found moderate dehydration, rhinorrhea, diminished air exchange in the left chest, rales at the left base, and no physical signs of respiratory distress. Wheezing was not found, but the expiratory phase was prolonged. Tables 1 and 2 summarize the arterial blood gas (ABG) values and respiratory interventions throughout the course of admission.

Eight hours after admission, the child was intubated for increased work of breathing and was initially placed on synchronized intermittent mandatory ventilation with pressure support. Table 1 shows the initial ventilator settings and ABG values. Peak inspiratory pressure on those settings was 42 cm H_2O and mean airway pressure was 14 cm H_2O. The child was started on intravenous methylprednisone and given albuterol aerosols every hour. Ceftriaxone and clindamycin were also administered intravenously for chest radiographic findings of pneumonia.

Table 1 shows the ventilator settings on hospital day 2. Peak inspiratory pressure on those settings was 30 cm H_2O, and mean airway pressure was 11 cm H_2O.

On hospital day 4, chest radiograph findings had progressed to show bilateral infiltrates consistent with ARDS. The nasopharyngeal swabs obtained on admission were positive for respiratory syncytial virus by direct fluorescent antibody testing.

On hospital day 5 the patient's respiratory status worsened. The mode of ventilation was switched to pressure

Table 2. Summary of Ventilator Settings and Blood Gas Values After APRV

Time	Mode	F_{IO_2}	P_H (cm H_2O)	P_L (cm H_2O)	T_H (s)	T_L (s)	Type	pH	P_{aCO_2} (mm Hg)	P_{aO_2} (mm Hg)
126 hours	APRV	1.0	28	8	2.7	0.8	ABG	7.37	69	78
128 hours	APRV	1.0	28	8	2.7	0.2	ABG	7.32	65	250
144 hours	APRV	0.6	28	7	2.3	0.2	ABG	7.40	63	106
216 hours	APRV	0.35	12	5	1.5	6.0	ABG	7.38	50	118
312 hours	Bipap	0.21	—	—	—	—	ABG	7.38	45	103

APRV = airway pressure release ventilation
F_{IO_2} = fraction of inspired oxygen
P_H = high pressure
P_L = low pressure
T_H = high time
T_L = low time
P_{aCO_2} = arterial partial pressure of carbon dioxide
P_{aO_2} = arterial partial pressure of oxygen
ABG = arterial blood gas
Bipap = bi-level positive airway pressure

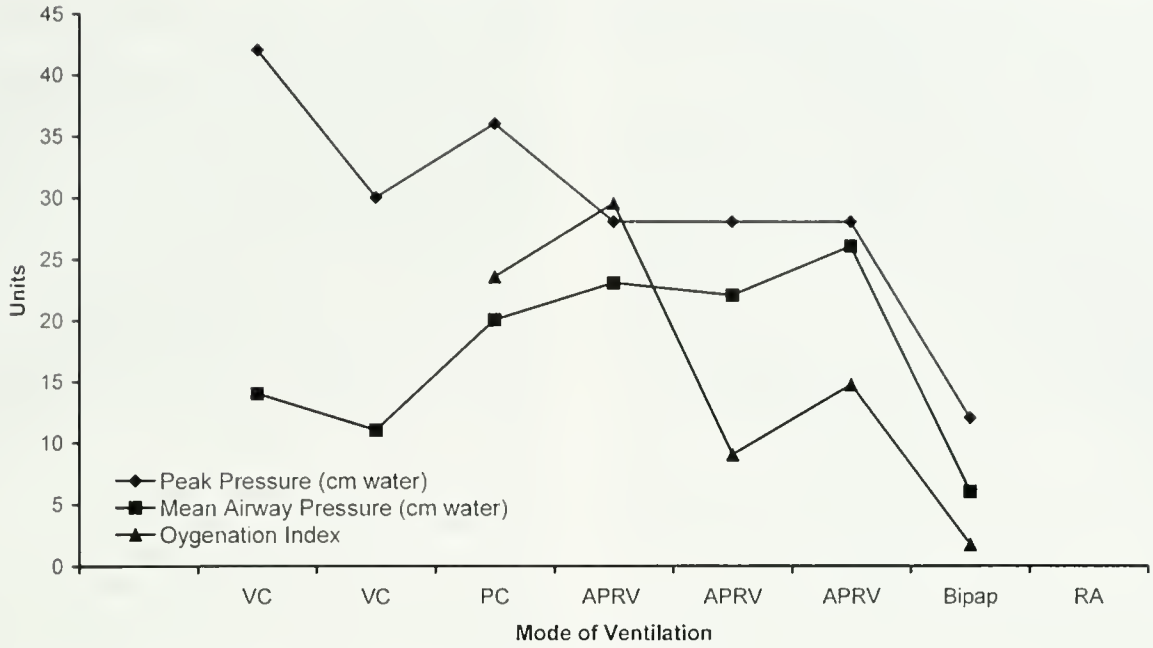

Fig. 1. Ventilator parameters and oxygenation index during intensive care unit admission. VC = volume control. PC = pressure control. Bipap = bi-level positive airway pressure. RA = room air.

control with the settings shown in Table 1. On these settings, exhaled return tidal volume (V_T) was 84 mL and mean airway pressure was 20 cm H_2O. The inspiratory time was set at 1.2 s (inspiratory time-to-expiratory time ratio 1:1.5). An ABG sample at that time found the P_{aO_2}/F_{IO_2} ratio (ratio of arterial partial pressure of oxygen to fraction of inspired oxygen) to be 85.

During manual bag ventilation for an episode of low blood oxygen saturation (in which oxygen saturation values, measured by pulse oximetry [S_{pO_2}], were in the 80–90% range), S_{pO_2} improved with a longer inspiratory phase; hence, a trial of APRV was initiated.

Table 2 shows the initial APRV settings and blood gas values. On those settings, mean airway pressure was 23 cm H_2O. The first ABG values (see Table 2) while on APRV indicated a P_{aO_2}/F_{IO_2} ratio of 78.

After shortening the release time to 0.2 s (128 h after admission), ABG values had improved and the P_{aO_2}/F_{IO_2} ratio was 250. At a release time of 0.2 s, exhaled V_T was 85 mL (5 mL/kg) and intrinsic positive end-expiratory pressure (PEEP) was 15 cm H_2O. By the following day (144 h after admission), F_{IO_2} was decreased to 0.6 while maintaining $S_{pO_2} > 90\%$ (see Table 2). Mean airway pressure was 26 cm H_2O. An ABG sample drawn at that time indicated a P_{aO_2}/F_{IO_2} ratio of 176.

At no time during the course of the hospital admission did the child require pharmacologic intervention to support his cardiovascular system, and within 3 days the ventilator settings were compatible with extubation. Table 2 shows the patient's last ventilator settings prior to extubation (216 h after admission). An ABG sample at that time indicated a P_{aO_2}/F_{IO_2} ratio of 337.

On hospital day 9, following a 45 min trial of synchronized intermittent mandatory ventilation with F_{IO_2} 0.35, respiratory rate 8 breaths/min, V_T 150 mL, and PEEP 5 cm H_2O, the child was extubated to supplemental oxygen via nasal cannula. Following extubation, the patient had upper airway obstruction secondary to pharyngeal hypotonia. The obstruction was relieved by noninvasive PPV.

By hospital day 13, the patient was weaned to room air. Table 2 shows ABG values obtained at that time. The child was discharged to his original long-term care facility 23 days after admission (Fig. 1).

Discussion

This case demonstrates a unique approach to the management of a child with ARDS. Medically complicated children in respiratory distress often require ventilatory support in pediatric intensive care. Frequently, these children progress into ARDS and fail therapy with conventional PPV, requiring high-frequency oscillatory ventilation or inverse ratio ventilation. The child reported in this case had an evolving ARDS that failed conventional therapy. This child, however, benefited from a relatively new method of ventilation in the pediatric population: APRV. The case illustrates that the benefits of APRV that have been shown in adults, such as ventilating at lower peak airway pressure, allowing spontaneous breathing, and avoiding use of heavy sedation and neuromuscular block-

ade, might also benefit the pediatric population. Additionally, the child in this case benefited from a release time that was shorter than previously reported.

APRV has been used successfully in adults and has been shown to be an effective alternative to conventional PPV in patients with acute lung injury and ARDS.[1–3] In acute lung injury, APRV has been shown to be as effective as inverse ratio ventilation.[4] APRV has many advantages over other methods of ventilation such as conventional PPV or high-frequency oscillatory ventilation. APRV may cause less cardiovascular depression than conventional PPV.[5] In patients recovering from cardiopulmonary bypass, APRV was shown to support oxygenation and ventilation without depressing cardiac function to the same extent as conventional PPV.[1] Compared to conventional PPV, APRV improves ventilation-perfusion matching and leads to better ventilation.[2,6–8] APRV may reduce barotrauma by ventilating at lower peak airway pressures.[2,9] APRV also has the major advantage of allowing the patient to breathe spontaneously during the entire respiratory cycle, while providing ventilatory support. Spontaneous breathing has been shown to improve right ventricular end diastolic volume, stroke volume, cardiac index, P_{aO_2}, oxygen delivery, ventilation-perfusion mismatch, and dead space.[6,10] Additionally, by allowing the patient to breathe spontaneously, APRV does not require the use of heavy sedation and paralytic agents (as in pressure control with inverse ratio ventilation and high frequency oscillatory ventilation), medications that have morbidity associated with their use.

Little has been published regarding the use of APRV in the pediatric population.[11–14] In our patient, ventilation and oxygenation were optimally provided at a shorter release time (0.2 s) than previously reported in adults.[2] This is consistent with the work by Martin and Wetzel, with neonatal sheep, in which they found that poorly compliant lungs require a short release time to maintain oxygenation and ventilation, in order to avoid atelectasis.[15] In this patient, a trial of 0.8 s for the release time did not provide the necessary support to prevent hypoxia and hypercapnia, compared to the shorter release time of 0.2 s. The release time during APRV is determined by the time constant of the lungs (airway resistance and lung-thorax compliance). In severe ARDS, time constants are reduced secondary to impaired compliance, requiring a short release time. In general, children have higher respiratory rates at baseline and therefore have shorter respiratory cycles. In the presence of ARDS, the time constant is shorter than normal, which may have explained the need for an even shorter release time than in adults (release time of 0.2 s vs $>$ 0.5 s). The patient's ABG improvement on a short release time reflects the severity of his ARDS and the degree of impairment of his compliance. The improvement of oxygenation in this case could be related to the increase of the intrinsic PEEP.

This case highlights that when using APRV the operator must be aware that pressures used to keep alveoli from collapsing are not set by manipulation of the extrinsic PEEP directly, but are a function of intrinsic PEEP, which is created by shortening the release time and controlling the low pressure.

The improvement of oxygenation following the initiation of APRV with a short release time and the increase in the intrinsic PEEP could have been achieved by using synchronized intermittent mandatory ventilation or pressure control ventilation and increasing the level of the extrinsic PEEP. One of the advantages of APRV is the ability to ventilate the patient with an elevated intrinsic PEEP without heavy sedation and neuromuscular blockade, which was attractive in this situation.

A lung-protective ventilation strategy is becoming the standard of care, and its use decreases mortality by 22% in ARDS patients.[16] Our patient was ventilated with a return V_T of 85 mL (5 mL/kg) and an intrinsic PEEP of 15 cm H_2O, which is a strategy compatible with the recommendations of the ARDS Network[16] and a lung-protective (low V_T) ventilation strategy.

This case report has shown that pediatric patients with ALI or ARDS may benefit from APRV, which has many advantages over conventional ventilation. It causes less cardiovascular depression, improves ventilation-perfusion matching, permits ventilation to occur at lower airway pressures, and allows the patient to breathe spontaneously on high ventilator settings, avoiding the need for neuromuscular blockade or heavy sedation.

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Implementation of a Low Tidal Volume Ventilation Protocol for Patients with Acute Lung Injury or Acute Respiratory Distress Syndrome

Richard H Kallet MS RRT, Wanda Corral RN, Henry J Silverman MD, and John M Luce MD

Introduction
Overview and Implementation
  Continuous Mechanical Ventilation Protocol
  Weaning Protocol
Management Problems During Low Tidal Volume Ventilation
  Use of Pressure-Targeted Ventilation, Inspiratory Plateau Pressure, and Positive End-Expiratory Pressure Target Goals
  Dyspnea and Patient-Ventilator Discoordination
  Acidosis
  Hemodynamic Consequences of Low Tidal Volume Ventilation
  Pulmonary Hygiene
  Discontinuation of Mechanical Ventilation
In Conclusion

The ARDS (acute respiratory distress syndrome) Network study found 22% lower mortality in acute lung injury and ARDS patients ventilated with low tidal volumes (V_T) than in those ventilated with traditional V_T ventilation. Several points should be considered when using the low V_T protocol for clinical practice. Prior to implementation, hemodynamic and acid-base status, minute ventilation, and adequacy of sedation should be assessed to minimize the potential for intolerance. The volume-preset, assist-control mode is recommended for better control of V_T, and the respiratory rate should be increased as V_T is reduced, so as to maintain minute ventilation and prevent acute hypercapnia. When unavoidable, hypercapnia should be induced slowly. Ventilator inspiratory flow ($\dot{V}_I$) and trigger sensitivity settings should be optimized to limit the increase in work of breathing and dyspnea. When dyspnea results in double-triggered breaths, V_T can be titrated to 7–8 mL/kg, provided end-inspiratory plateau pressure is $\leq$ 30 cm H_2O. In severe acidosis (pH < 7.15) V_T also can be increased. However, every effort should be made to maintain plateau pressure and V_T goals by buffering severe acidosis and treating patient-ventilator asynchrony with sedation. Evaluation for weaning should occur when adequate oxygenation can be maintained on 40% oxygen and a positive end-expiratory pressure of 8 cm H_2O. Pressure support levels between 5 and 20 cm H_2O (above 5 cm H_2O positive end-expiratory pressure) are used for weaning and titrated to keep the respiratory rate < 35 breaths/min. Pressure support levels should be weaned aggressively, as long as the protocol's weaning tolerance criteria can be maintained. *Key words: acute lung injury, acute respiratory distress syndrome, low tidal volume ventilation, lung-protective ventilation protocol.* [Respir Care 2001;46(10):1024–1037]

Introduction

Ventilator-induced lung injury contributes to the progression of acute lung injury (ALI) and acute respiratory distress syndrome (ARDS).[1] It occurs, in part, from the unequal distribution of a super-normal tidal volume (V_T) to normal areas of the lung when diseased areas are resistant to recruitment and expansion.[2] The resulting alveolar overdistention causes alveolar-capillary membrane damage,[3] increased-permeability pulmonary edema,[4] and hyaline membrane formation.[5] Therefore, in patients with ALI or ARDS, V_T should be reduced to 6–7 mL/kg to limit the end-inspiratory plateau pressure (P_{plat}) to $\leq$ 30 cm H_2O.[6] If necessary, V_T should be reduced to 4 mL/kg to accomplish that goal.[6]

Recently, the ARDS Network (funded by the National Heart Lung and Blood Institute) published a study indicating 22% lower mortality with a low V_T ventilation strategy in patients with ALI or ARDS.[7] The ARDS Network protocol reduces V_T to between 6 and 4 mL/kg to limit P_{plat} to $\leq$ 30 cm H_2O. Achieving comparable mortality reductions in clinical practice may require adaptation of the entire protocol strategy. Therefore, as members of the ARDS Network, we have written this article as a guide for clinicians who wish to adapt the ARDS Network's research protocol to manage ALI and ARDS patients. We provide an overview of the ARDS Network low V_T ventilation protocol and describe its implementation. In addition, we discuss relevant respiratory care and nursing issues based on management problems during low V_T ventilation. Our recommendations are based primarily on our clinical experience with patients enrolled in the ARDS Network low V_T study.

At the outset, we wish to stress that the ARDS Network low V_T protocol was designed for patients with ALI and has been shown to reduce mortality in that patient population. Although we think it is prudent to manage mechanically ventilated patients at lower V_T (perhaps < 10 mL/kg), there is no evidence from large, prospective, randomized trials that a low V_T protocol benefits patients without pulmonary disease. Long before lung-protective ventilation was used in ALI/ARDS, Darioli and Perret[8] reported the mortality benefits of limiting ventilator pressures and V_T in patients with status asthmaticus. However, in obstructive lung diseases the alterations in pulmonary mechanics are fundamentally different and thus require a much different approach to achieving lung-protective ventilation. Therefore, without careful consideration of the specific lesions and alterations in mechanics, we cannot recommend *exact* utilization of the ARDS Network research protocol in other pulmonary diseases. Furthermore, there are conditions that may coincide with ALI (such as acute brain injury, acute myocardial infarction, tricyclic antidepressant overdose, and sickle cell crisis) in which the protocol should be deferred, modified, or implemented with extreme caution to prevent potential complications associated with acute hypercapnia.

Overview and Implementation

Patients managed with the ARDS Network protocol met American-European Consensus Conference[9] criteria: acute onset, P_{aO_2}/F_{IO_2} (ratio of arterial partial pressure of oxygen to fraction of inspired oxygen) $\leq$ 300 mm Hg, bilateral infiltrates on frontal chest radiograph, and pulmonary arterial occlusion pressure $\leq$ 18 mm Hg (or no evidence of left atrial hypertension). The ARDS Network low V_T ventilation protocol has 2 components: a continuous mechanical ventilation protocol governing the acute phase of ALI or ARDS and a weaning protocol that governs the recovery phase. During the acute phase patients are managed with volume-targeted "assist-control" mechanical ventilation, although the protocol probably could be adapted to a pressure-targeted approach. The continuous mechanical ventilation portion of the protocol contains 5 interdependent algorithm parts that control V_T, P_{plat}, arterial pH, and oxygenation (Fig. 1).

Continuous Mechanical Ventilation Protocol

Initiating the continuous mechanical ventilation protocol occurs in 4 steps.

First, V_T is set according to predicted body weight (PBW) and adjusted down to 6 mL/kg within the first 4 hours of protocol implementation. Because normal lung volumes are predicted on the basis of height and sex,[10,11] the patient's height is measured to determine the PBW and calculate the appropriate V_T. PBW is determined by the following formulas:*

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* When height is measured in centimeters the formula is adjusted as follows: Male: PBW in kg = 50 + 2.3 [(height in cm − 152) ÷ 2.54]. Female: PBW in kg = 45.5 + 2.3 [(height in cm − 152) ÷ 2.54].

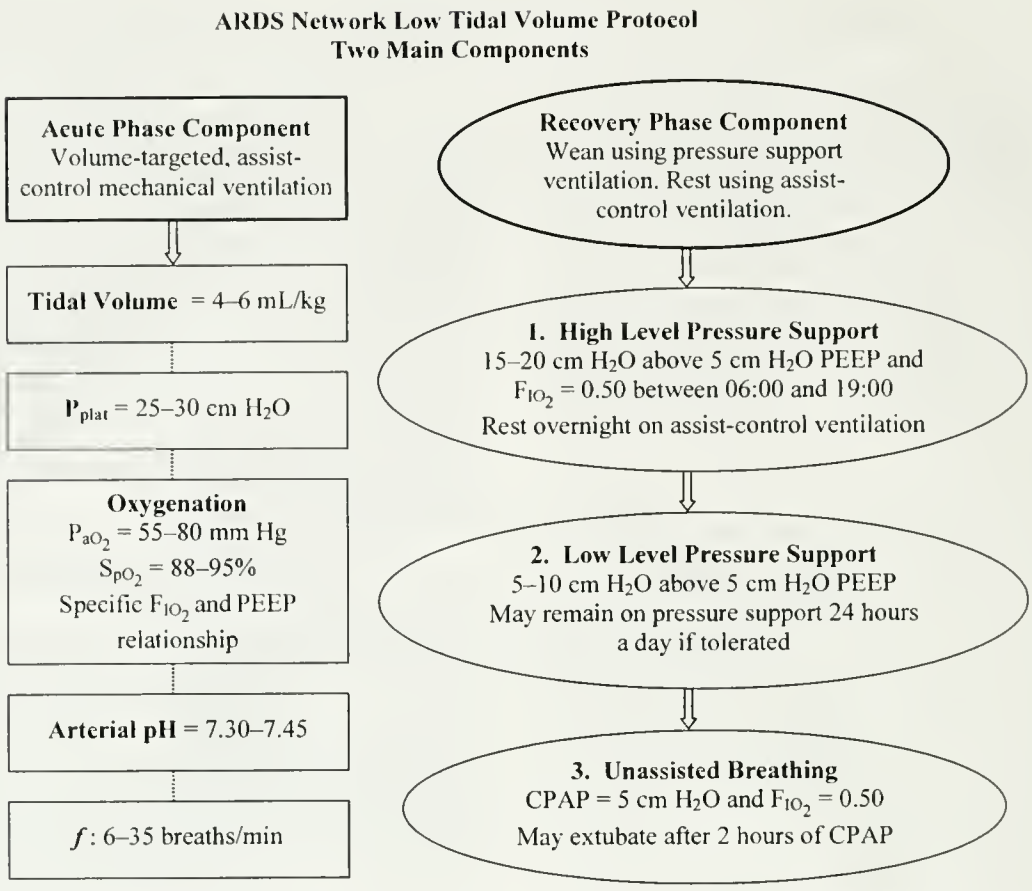
ARDS Network Low Tidal Volume Protocol
Two Main Components
Acute Phase Component
Volume-targeted, assist-control mechanical ventilation
Tidal Volume = 4–6 mL/kg
P_{plat} = 25–30 cm H_2O
Oxygenation
P_{aO_2} = 55–80 mm Hg
S_{pO_2} = 88–95%
Specific F_{IO_2} and PEEP relationship
Arterial pH = 7.30–7.45
f: 6–35 breaths/min
Recovery Phase Component
Wean using pressure support ventilation. Rest using assist-control ventilation.
1. High Level Pressure Support
15–20 cm H_2O above 5 cm H_2O PEEP and
F_{IO_2} = 0.50 between 06:00 and 19:00
Rest overnight on assist-control ventilation
2. Low Level Pressure Support
5–10 cm H_2O above 5 cm H_2O PEEP
May remain on pressure support 24 hours a day if tolerated
3. Unassisted Breathing
CPAP = 5 cm H_2O and F_{IO_2} = 0.50
May extubate after 2 hours of CPAP

Fig. 1. The ARDS Network low tidal volume (V_T) protocol's 2 main components.[7] The acute phase component (left) uses volume-targeted, continuous mechanical ventilation with 5 interdependent algorithm parts. The recovery phase component (right) uses graded pressure support ventilation to facilitate the patient's transition to unassisted breathing. ARDS = acute respiratory distress syndrome. P_{plat} = inspiratory plateau pressure. P_{aO_2} = arterial partial pressure of oxygen. S_{pO_2} = arterial oxygen saturation measured by pulse oximetry. F_{IO_2} = fraction of inspired oxygen. PEEP = positive end-expiratory pressure. f = respiratory rate. CPAP = continuous positive airway pressure.

Male: PBW in kg = 50 + 2.3 (height in inches − 60)

Female: PBW in kg = 45.5 + 2.3 (height in inches − 60)

Height is measured from heel to crown with the patient in the supine position. Then, to determine the delivered V_T, the PBW is multiplied by 6 mL/kg. The inspired V_T is measured for all protocol changes because, during assisted ventilation, expired V_T may significantly change on a breath-to-breath basis. To prevent "nuisance" ventilator adjustments, the V_T is allowed to vary by ± 0.5 mL/kg as long as P_{plat} is ≤ 30 cm H_2O.

Second, the ventilator-set V_T is corrected for compression volume loss from pressurizing the ventilator circuit.[12] Accounting for compression volume loss is important during low V_T ventilation because changes in lung mechanics that affect compression volume loss can substantially alter minute ventilation ($\dot{V}_E$) and may limit precise control of lung stretch. For example, a random sample of 100 compression volume data points (with disposable ventilator circuits) was collected from 20 patients in the low V_T group at San Francisco General Hospital. Compression volume was 92 ± 28 mL (1.5 mL/kg) or 19 ± 6% of the preset V_T.

Compression volume loss is calculated by measuring the ventilator circuit compliance (see Appendix). Most ventilators feature automatic V_T compensation,[12] so that once ventilator circuit compliance is determined, the ventilator automatically increases the delivered V_T to compensate for compressible volume loss. Alternatively, a bedside pulmonary mechanics monitor can be used to measure V_T at the circuit Y-piece, which reflects the actual V_T delivered to the patient.[12] Otherwise, this calculation can be performed manually or added to a bedside computer

Table 1 Relationship Between PEEP and F_{IO_2} Settings in the ARDS Network Protocol

F_{IO_2}	0.30	0.40	0.40	0.50	0.50	0.60	0.70	0.70	0.70	0.80	0.90	0.90	0.90	1.0	1.0	1.0
PEEP	5	5	8	8	10	10	10	12	14	14	14	16	18	18	20–24	26–34*

*When arterial partial pressure of oxygen (P_{aO_2}) < 55 mm Hg (or arterial oxygen saturation measured by pulse oximetry [S_{pO_2}] < 88%) on fraction of inspired oxygen (F_{IO_2}) = 1.0 and positive end-expiratory pressure (PEEP) = 24 cm H_2O, then the inspiratory time-to-expiratory time ratio (I:E) is increased to 1:1 and PEEP is increased in increments of 2 cm H_2O until a maximum of 34 cm H_2O or until P_{aO_2} > 55 mm Hg (or S_{pO_2} > 88%). If no improvement occurs by 4 hours, then PEEP is decreased to 24 cm H_2O. ARDS = acute respiratory distress syndrome. (Adapted from Reference 7.)

program. Corrected V_T can be determined by the following formulas:[12]

$$\text{Compression volume} = \text{circuit compliance} \times (\text{PIP} - \text{PEEP})$$

$$\text{Corrected } V_T = \text{pre-set } V_T - \text{compression volume}$$

wherein PIP is peak inspiratory pressure and PEEP is positive end-expiratory pressure.

Third, as V_T is reduced, $\dot{V}_E$ is maintained by increasing the pre-set respiratory rate (f). To determine the new f, divide the $\dot{V}_E$ by the target V_T. For example, if the patient's $\dot{V}_E$ is 15 L/min and the target V_T is 0.5 L, then the new f = 30 breaths/min.

A common misconception is that low V_T ventilation necessarily requires permissive hypercapnia. Because the protocol limits the preset f to 35 breaths/min, hypercapnia generally is induced only when the baseline $\dot{V}_E$ cannot be matched by the new ventilator settings (eg, when the baseline $\dot{V}_E$ is high) or the V_T must be reduced toward 4 mL/kg. If necessary, hypercapnia should be induced slowly so that the arterial partial pressure of carbon dioxide (P_{aCO_2}) does not rise more than 10 mm Hg/h.[13] The protocol allows for the V_T to be reduced to 6 mL/kg over 4 h.[7] Further reductions in V_T can be made, by 1 mL/kg over 2–3 h, if necessary.[7] Additional protocol-directed ventilator adjustments include setting the inspiration-expiration ratio between 1:3 and 1:1. Ventilator inspiratory flow ($\dot{V}_I$) and flow waveform can be set at the clinician's discretion.

Fourth, once the target V_T is established, its effect on P_{plat} and oxygenation must be considered. V_T is aggressively reduced so that P_{plat} is between 25 and 30 cm H_2O,[7] because important lung injury may occur even at P_{plat} < 30 cm H_2O.[14,15] P_{plat} is measured using a 0.5 s end-inspiratory pause-hold. It is important to ensure that the patient is not coughing, continuing to inspire, or actively expiring during the P_{plat} measurement. Historically, low V_T ventilation has been associated with progressive atelectasis[16,17] and increased alveolar-arterial oxygen tension gradient,[16–18] especially during hypercapnia.[17] When rapidly induced (in ≤ 60 min), permissive hypercapnic ventilation has been shown to increase intrapulmonary shunt, in part from the hemodynamic effects of acute respiratory acidosis.[19,20] Therefore, adjustments in F_{IO_2} and PEEP are sometimes necessary. Yet, the ARDS Network study[7] and other studies[21–23] have not shown that large increases in F_{IO_2} or PEEP are generally required as V_T is reduced.

The F_{IO_2}/PEEP grid determines the appropriate F_{IO_2} for any given PEEP level (Table 1). During initiation of the protocol, F_{IO_2}, PEEP, or both are adjusted in intervals of 5–15 minutes, until F_{IO_2}/PEEP are compatible with the protocol. For example, if the patient is on F_{IO_2} of 0.70, PEEP of 10 cm H_2O, and has a P_{aO_2} 90 mm Hg, then F_{IO_2} is decreased to 0.60. In contrast, if P_{aO_2} is 54 mm Hg on F_{IO_2} of 0.70 and PEEP of 10 cm H_2O, then PEEP is increased to 12 cm H_2O to raise P_{aO_2}. If PEEP is increased, then P_{plat} is re-measured to evaluate the need for reducing V_T below 6 mL/kg.

The protocol range for blood oxygen saturation (measured by pulse oximetry) is 88–95% and the range for P_{aO_2} is 55–80 mm Hg.[7] These ranges allow patients to be managed with mild hypoxemia rather than increasing high levels of PEEP and F_{IO_2} further. In addition, the upper limit of oxygenation compels prompt changes in either F_{IO_2} or PEEP in response to improvement. These frequent challenges are used to facilitate movement toward the weaning arm of the trial.

In the presence of severe acidosis or hypoxemia, the protocol permits temporary suspension of the upper P_{plat} limit. When severe patient-ventilator discoordination occurs, V_T can be increased to 7–8 mL/kg as long as P_{plat} is ≤ 30 cm H_2O (Table 2). The pre-set f is adjusted to between 6 and 35 breaths/min to maintain arterial pH between 7.30 and 7.45. Sodium bicarbonate can be used to treat severe acidosis (see Table 2).

Weaning Protocol

A patient enters the weaning protocol when the following criteria are met:

1. At least minimum levels of stable oxygenation can be maintained on F_{IO_2} 0.40 and PEEP 8 cm H_2O.
2. F_{IO_2} and PEEP have either decreased or have remained stable during the previous day.

Table 2. Conditions Under Which Tidal Volume, Respiratory Rate, or Other Protocol Adjustments Are Made

Condition	V_T, f, and other protocol adjustments
$P_{plat} > 30$ cm H_2O	↓ V_T by 1 mL/kg every 2–3 h, to a minimum of 4 mL/kg ↑ f to maintain $\dot{V}_E$
$P_{plat} < 25$ cm H_2O and $V_T < 6$ mL/kg	↑ V_T to 6 mL/kg and ↓ f to maintain $\dot{V}_E$
Mild acidosis: pH 7.15–7.30	↑ f to 35 breaths/min or until pH ≥ 7.30 with $P_{aCO_2} \geq 25$ mm Hg If pH remains < 7.30 and $P_{aCO_2} < 25$ mm Hg, consider treatment with sodium bicarbonate
Severe acidosis: pH < 7.15	↑ f to 35 breaths/min and consider treatment of pH with sodium bicarbonate If pH remains < 7.15, ↑ V_T by 1 mL/kg until pH > 7.15 $P_{plat} > 30$ cm H_2O is acceptable Upper limits of V_T and P_{plat} are suspended until pH = 7.20
Severe hypoxemia: $P_{aO_2} < 55$ mm Hg ($S_{pO_2} < 88\%$) on $F_{IO_2} = 1.0$ and PEEP = 24 cm H_2O	Upper limits of V_T and P_{plat} are suspended during PEEP trial between 26 and 34 cm H_2O I:E is set at 1:1
Severe patient-ventilator discoordination: The failure of the ventilator to pressurize the circuit above PEEP during inspiration, or double-triggering the ventilator during inspiration (> 3 occurrences/min)	↑ f and ↓ I:E to ↑ V_I Maximize trigger sensitivity If available on volume mode, use decelerating flow pattern to ↑ V_I If above measures ineffective and $P_{plat} < 30$ cm H_2O, ↑ V_T by 1 mL/kg up to 8 mL

P_{plat} = end-inspiratory plateau pressure
↓ = decrease
V_T = tidal volume
↑ = increase
f = respiratory rate
$\dot{V}_E$ = minute ventilation
P_{aCO_2} = arterial partial pressure of carbon dioxide
P_{aO_2} = arterial partial pressure of oxygen
S_{pO_2} = arterial oxygen saturation measured by pulse oximetry
F_{IO_2} = fraction of inspired oxygen
PEEP = positive end-expiratory pressure
I:E = ratio of inspiratory time to expiratory time
V_I = inspiratory flow rate

3. The patient is not receiving a neuromuscular blocking agent and there is no evidence of neuromuscular blockade.

4. Systolic blood pressure is ≥ 90 mm Hg without vasopressor support.[†]

Patients are evaluated for weaning between 6:00 AM and 10:00 AM. If a patient is not triggering breaths from the ventilator, then the mandatory f is reduced by 50% for 5 minutes. If no breaths are triggered after 5 minutes, then the patient does not meet weaning criteria for that day (although patients can be re-evaluated after sedation is decreased). If the patient is triggering breaths from the ventilator, he or she is placed on continuous positive airway pressure (CPAP) at 5 cm H_2O, with F_{IO_2} of 0.50 for 5 minutes. At 5 minutes of CPAP, if f is ≤ 35 breaths/min and there are no signs of intolerance (Table 3), then weaning with pressure support (PS) ventilation is initiated. However, if f is > 35 breaths/min at the end of the 5 minutes CPAP trial or there are signs of intolerance, the patient is placed back on "assist-control" ventilation. If excessive tachypnea/intolerance is caused by anxiety, another CPAP trial is initiated after sedation has been adjusted.

PS is set between 5 and 20 cm H_2O (in increments of 5 cm H_2O) above 5 cm H_2O of PEEP, depending on either f or signs of intolerance (Fig. 2). The initial level of PS is determined by the patient's f at 5 minutes of CPAP. At the end of the CPAP trial, if f is ≤ 25 breaths/min, the patient is placed on the minimum level of PS for 2 hours. After 2 hours at the minimum PS, if f is ≤ 35 breaths/min, the patient is returned to CPAP of 5 cm H_2O. After 2 hours of CPAP, if f is ≤ 35 breaths/min, then the patient can be extubated and placed on a T-piece with supplemental oxygen or remain on CPAP of 5 cm H_2O.

In contrast, if at the end of the CPAP trial f is 26–35 breaths/min, then the patient is placed on the highest level of PS (20 cm H_2O). The patient is challenged with a 5 cm H_2O decrement in PS at least every 3 hours. In addition, if f falls below 26 breaths/min at any time, then the PS level

[†] Dopamine or dobutamine infusions of ≤ 5 μg/kg/min are not considered vasopressor support.

Table 3 Criteria Used to Assess Weaning Tolerance

Total f ≤ 35 breaths/min (< 35 breaths/min for < 5 min is allowed)
S_{pO_2} ≥ 88% (< 88% for < 15 min is allowed)
No respiratory distress, defined as 2 or more of the following:
- Heart rate > 120% of 6:00 AM value (< 120% for < 5 min is allowed)
- Pronounced accessory muscle use
- Abdominal paradox
- Diaphoresis
- Pronounced subjective sense of dyspnea

f = respiratory rate
S_{pO_2} = arterial oxygen saturation measured by pulse oximetry

is decreased by 5 cm H_2O as often as necessary. During PS weaning trials, if f exceeds 35 breaths/min for > 5 min, then the PS level is increased in 5 cm H_2O increments until f decreases to 35 breaths/min. If that cannot be achieved at the highest level of PS (20 cm H_2O), then the patient is returned to assist-control ventilation on the low V_T protocol until the following morning. Weaning is resumed at the last PS level used on the previous day.

Management Problems During Low Tidal Volume Ventilation

Use of Pressure-Targeted Ventilation, Inspiratory Plateau Pressure, and Positive End-Expiratory Pressure Target Goals

With publication of positive studies such as the ARDS Network trial[7] and the "open-lung approach,"[24] questions have been raised regarding both the best method of achieving lung-protective ventilation and what pressure target goals should be set for P_{plat} and PEEP. Pressure-targeted modes of ventilation are used for lung-protective ventilation.[6,24,25] However, in these modes, V_T is determined mainly by transpulmonary pressure, so that V_T will vary directly with patient inspiratory effort.[26] Therefore, during patient-triggered breaths, lung overdistention can occur despite an appropriately set airway pressure target.[6] In these studies[6,24,25] great care was taken to ensure that V_T did not exceed 6 mL/kg, by liberal use of sedation and, in some instances,[25] neuromuscular blocking agents. Because volume-targeted ventilation offers the best control over V_T, and this was the mode used in the ARDS Network study, we recommend that lung-protective ventilation should at least commence with this mode of ventilation.

The P_{plat} pressure target of ≤ 30 cm H_2O requires comment. When the concept of lung-protective ventilation in ARDS was first developed, a P_{plat} of 35–40 cm H_2O was chosen[27,28] based on evidence of lung injury from animal studies and the fact that the normal lung is maximally distended at a similar transpulmonary pressure. Over the years, the target P_{plat} was reduced in clinical trials,[7,21] as evidence from animal studies suggested that lung injury occurs at peak alveolar pressures below 30 cm H_2O.[13-15] One interpretation of those lung-protective ventilation trials[7,21-24] is that the positive trials were the ones that produced the largest reductions in P_{plat}.[29] A P_{plat} above 32 cm H_2O appeared to be predictive of a higher mortality risk.[29] However, the ARDS Network study found improved survival at a mean P_{plat} of 26 cm H_2O, suggesting that reducing P_{plat} below 30 cm H_2O is an important goal. The issue of an appropriate P_{plat} target in ALI has been complicated by the concept of "volutrauma,"[30] which suggests that under circumstances of diminished chest wall compliance (C_{CW}), lung overdistention is unlikely to occur at the anticipated P_{plat} because transpulmonary pressure is reduced.[31] When C_{CW} is globally reduced (as occurs with generalized tissue edema from sepsis[32]), then relaxation of P_{plat} goals appears reasonable. However, the mechanical properties of the chest wall are complex and do not conform to simplistic models of a single elastic structure coupled to the lungs. The chest wall includes both the rib cage and the abdominal wall, each with its own distinct compliance.[33] During controlled mechanical ventilation, the rib cage is more compliant than the abdominal wall and accounts for over 70% of thoracic displacement during tidal ventilation in the supine position.[33] As a result, both low V_T ventilation and the volume-enhancing effects of PEEP are preferentially distributed to the ventral portions of the lung.[34] This discrepancy between rib cage and abdominal wall contributions to C_{CW} becomes particularly important under conditions of markedly elevated intra-abdominal pressure.[35] Therefore, an appropriate "lung-protective" V_T when C_{CW} is normal may cause regional overdistention and ventilator-induced lung injury when C_{CW} is diminished because of increased intra-abdominal pressure. Although P_{plat} of 30 cm H_2O is seldom realized in patients with diminished C_{CW} from elevated intra-abdominal pressure, the goal of *minimizing* P_{plat} should not be abandoned.

Appropriate titration of PEEP has been the major focus of ventilator management in ARDS for over 30 years. In contrast to the ARDS Network study, the open-lung approach[24] incorporated higher levels of PEEP, which were determined by identifying a lower inflection point on a pressure-volume curve of the lung-thorax.[36] This point is believed to represent a zone where applied pressure results in substantial lung recruitment.[36] Setting PEEP by the open lung approach is based on evidence that repetitive sheer stress injury develops from cyclic reexpansion and collapse of atelectatic lung during tidal ventilation.[37] Although high levels of PEEP may reduce repetitive sheer injury, it also may cause lung injury from regional lung overdistention.[38] At this point, the safety of using high PEEP levels

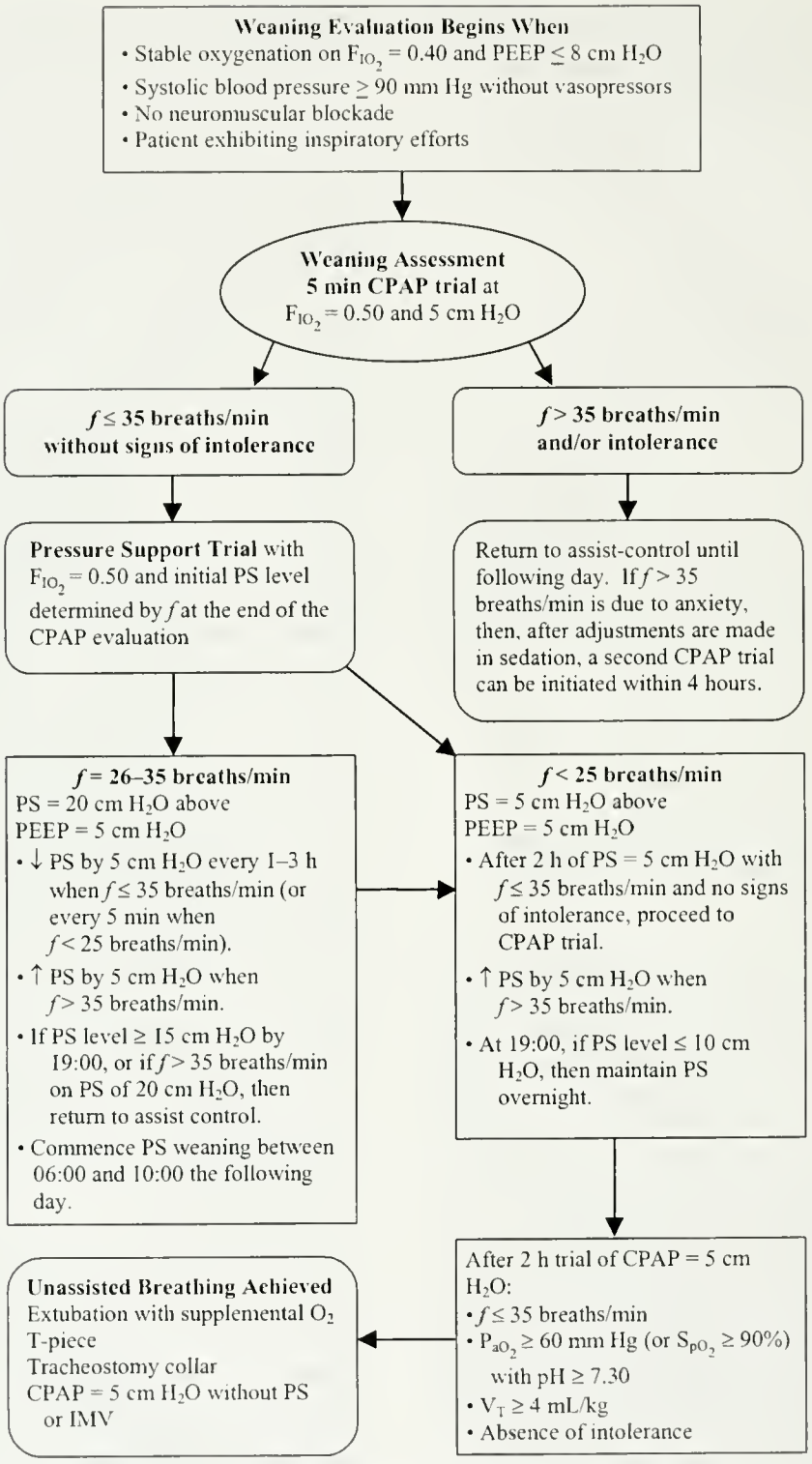

Fig. 2. The ARDS Network protocol for weaning a patient from assist control ventilation to unassisted breathing.[7] F_{IO_2} = fraction of inspired oxygen. PEEP = positive end-expiratory pressure. CPAP = continuous positive airway pressure. f = respiratory rate. PS = pressure support. P_{aO_2} = arterial partial pressure of oxygen. S_{pO_2} = arterial oxygen saturation measured by pulse oximetry. V_T = tidal volume. IMV = intermittent mandatory ventilation.

(in terms of lung injury) in ARDS remains undetermined.[38] Currently the ARDS Network is conducting a study to compare a higher PEEP/lower F_{IO_2} strategy to the PEEP/F_{IO_2} strategy used in the original study.[7]

Dyspnea and Patient-Ventilator Discoordination

During assisted ventilation, dyspnea and patient-ventilator discoordination are common problems associated with low V_T ventilation.[39] Patient-ventilator discoordination and the related increased work of breathing (WOB) generally occurs when either the ventilator $\dot{V}_I$,[40] or V_I,[41] is set below patient demand, and may be potentiated by increased respiratory drive from acute hypercapnia.[40,42] However, hypercapnia has a direct central effect on breathlessness that is independent from dyspnea that arises with increased breathing effort.[43] Therefore, even when ventilator adjustments successfully reduce patient WOB, it may not necessarily result in patient tolerance of low V_I ventilation. Dyspnea has been documented during hypercapnia and reduced V_I ventilation in quadriplegic patients.[44,45] Yet in normal subjects, dyspnea is proportional to the degree that V_I is voluntarily constrained below the spontaneously chosen target during acute hypercapnia.[46] Intense dyspnea persists in hypercapnic normal subjects despite complete neuromuscular blockade and controlled mechanical ventilation at a traditional V_T.[47] Therefore, sedation requirements should be reassessed automatically whenever permissive hypercapnia is needed to maintain low V_T ventilation.

Increased patient WOB may decrease arterial oxygenation and confuse the interpretation of a patient's clinical status.[41] Hypoxemia arising from patient-ventilator discoordination can occur by at least 3 mechanisms. First, the increased respiratory muscle oxygen consumption from increased WOB[48,49] may lower mixed venous oxygen saturation, thereby magnifying intra-pulmonary shunt. The respiratory muscles normally account for approximately 2% of total oxygen consumption,[50] but during acute distress respiratory muscle oxygen consumption can increase to 20–27%.[48,51] Second, intense negative swings in intrathoracic pressure may increase the transvascular pressure gradient, favoring pulmonary edema formation.[41] Third, increased expiratory intrathoracic pressure from expiratory muscle activity may counteract the beneficial effects of PEEP on alveolar recruitment.[52]

Often, patient-ventilator coordination can be improved by increasing $\dot{V}_I$,[40] increasing the trigger-sensitivity level[53] (either by reducing the absolute pressure threshold at which an inspiratory effort is "captured" by the ventilator or by changing to a flow-trigger system[54]), and by changing the inspiratory flow pattern to a decelerating profile.[55] Increasing $\dot{V}_I$ and trigger sensitivity unloads the inspiratory muscles[40,53] and lowers respiratory drive.[56] Increasing $\dot{V}_I$ also may improve patient-ventilator coordination by shortening the patient's neural inspiratory time, thereby decreasing the portion of inspiration when a patient actively inspires.[57] We found that patient-ventilator coordination occasionally could be achieved with "overdrive suppression,"[40] whereby the set f is increased above the patient-triggered f. This sometimes requires a 15–25% increase[40] in $\dot{V}_I$ to decrease respiratory drive by inducing mild hypocarbia.[58,59] When these ventilator adjustments cannot eliminate patient-ventilator discoordination, the protocol allows for increasing V_T to 7–8 mL/kg, as long as $P_{plat} < 30$ cm H_2O (see Table 2). The clinical threshold for increasing V_I above 6 mL/kg is a consistent failure to pressurize the circuit above PEEP during inspiration, or "double-triggering" breaths (ie, 2 ventilator breaths for a single breathing effort)[60] that does not respond to increased sedation. Anecdotally, we have noticed a tendency toward improved patient-ventilator coordination at a V_I of approximately 7 mL/kg. However, in our experience, high levels of sedation are often necessary to eliminate severe respiratory distress and patient-ventilator discoordination, especially when V_T is decreased toward 4 mL/kg to maintain a P_{plat} of 30 cm H_2O.

The decision of whether to use sedatives or narcotics (or both) to treat patient-ventilator discoordination may be aided, in part, by how discoordination is manifested. Benzodiazepines, propofol, and opioids all reduce respiratory drive. In general, benzodiazepines and propofol tend to depress V_I, whereas opioids tend to depress f.[61] Patient-ventilator discoordination that arises from V_I-mismatching may manifest as a failure to pressurize the circuit above PEEP during inspiration, or "double-triggering" breaths from the ventilator (by sustained decompression of the ventilator circuit). In theory, this form of discoordination may be more effectively treated with a benzodiazepine or propofol. In contrast, patient-ventilator discoordination that is manifested by severe tachypnea with frequent pressure-cycling to expiration (ie, "popping-off") may suggest a degree of timing asynchrony[62,63] that might respond more effectively to treatment with an opioid.

However, patient-ventilator discoordination during low V_I ventilation in ARDS may require treatment with sedatives and narcotics, because hypercapnia commonly produces restlessness and anxiety,[64] and pulmonary edema can produce intense rapid-shallow breathing from stimulation of irritant receptors (C fibers) in the pulmonary interstitium.[65,66] As a rule, neuromuscular blockade should be used only when patient-ventilator discoordination and hypoxemia persist despite very high levels of sedation. Furthermore, because sedation may reduce energy expenditure by 20%,[67] the consequential decrease in carbon dioxide production may lessen hypercapnia and acidosis during low V_I ventilation.

Acidosis

When hypercapnia is unavoidable in order to maintain lung-protective ventilation, the ARDS Network protocol allows for a gradual reduction in V_T and $\dot{V}_E$. It is recommended that P_{aCO_2} should increase no more than 10 mm Hg/h.[13] Severe respiratory acidosis during low V_T ventilation can be managed relatively easily by allowing P_{aCO_2} to rise slowly over the course of several hours.[2,39]

For example, a patient about to be managed with the ARDS Network protocol has a P_{plat} of 35 cm H_2O and a $\dot{V}_E$ of 22 L/min. If the target V_T at 6 mL/kg is 0.5 L, then the maximum *f* of 35 breaths/min creates a $\dot{V}_E$ deficit of 4.5 L/min (ie, 22–17.5 L/min). The protocol allows V_T to be reduced by 1 mL/kg over 2–3 hours. For a patient with a PBW of 85 kg, this would amount to a 0.5–0.3 mL/kg/h (25–42 mL) V_T reduction, or a $\dot{V}_E$ reduction of 0.9–1.5 L/min per hour. A review of the literature suggests that a $P_{aCO_2} \leq 80$ mm Hg with an arterial pH ≥ 7.15 is generally well tolerated, provided that hypoxemia and hypovolemia are not present.[13] Interestingly, a review of mean P_{aCO_2} and pH data from low V_T ventilation studies[7,21–24] suggests that most ALI and ARDS patients can be managed with $P_{aCO_2} \leq 60$ mm Hg and pH ≥ 7.25.

Partial renal compensation of respiratory acidosis generally requires 24–48 hours.[68] Severe acidosis (pH < 7.15) can be corrected more rapidly, if necessary, by slowly infusing sodium bicarbonate. Rapid administration of sodium bicarbonate should be avoided, as the partial pressure of carbon dioxide of a bicarbonate solution exceeds 200 mm Hg (or approximately 1 minute of normal CO_2 production).[68,69] Therefore, unless alveolar ventilation is doubled, respiratory acidosis will transiently worsen. In addition, because CO_2 readily diffuses across cell membranes, intracellular acidosis also may worsen.[13,68–70]

In contrast, severe metabolic acidosis and shock may complicate the use of low V_T ventilation, especially if permissive hypercapnia is required to reduce P_{plat}. In patients with ALI or ARDS, metabolic acidosis often is caused by lactic acidosis due to shock, hypoxemia, and multiorgan system failure.[71] Use of sodium bicarbonate in metabolic acidosis, especially under hypoxemic conditions, paradoxically may worsen metabolic acidosis and intracellular pH.[70] Furthermore, treatment of metabolic acidosis with sodium bicarbonate improves neither hemodynamic function nor cardiovascular response to catecholamines in patients with shock.[72]

The alternatives to sodium bicarbonate for treating lactic acidosis include sodium dichloroacetate, Carbicarb, and tris-hydroxymethyl aminomethane (THAM). Sodium dichloroacetate stimulates the oxidation of lactate to acetylcoenzyme A, but generates CO_2 in the process.[73] In a large clinical trial, sodium dichloroacetate caused only a small improvement in pH, compared to placebo.[73] Carbicarb (an equimolar solution of sodium bicarbonate and sodium carbonate) improves pH better than does sodium bicarbonate,[74] but it is not available for clinical use in the United States [personal communication, Food and Drug Administration, 2001]. THAM (a weak base amino-alcohol) has a greater buffering capacity than sodium bicarbonate and is an effective intracellular buffer.[75] Protonated THAM is excreted by the kidneys, so that CO_2 production is not raised.[76] In a recent uncontrolled study of hypercapnic patients with ALI or ARDS, we found that THAM increased pH and decreased P_{aCO_2} at the same level of $\dot{V}_E$.[71] Therefore, THAM may be an effective alternative to treat metabolic acidosis in ALI or ARDS without abandoning low V_T ventilation.

Hemodynamic Consequences of Low Tidal Volume Ventilation

ARDS often presents with hemodynamic instability that is complicated by the need for high levels of PEEP. Low V_T ventilation may complicate hemodynamic management further. In general, the hemodynamic consequences of low V_T ventilation relate directly to the effects of hypercapnia[13,39] and indirectly to the effects of the high-level sedation needed to control patient-ventilator discoordination and to relieve dyspnea.[61] Acute hypercapnia causes transient myocardial depression and decreased systemic vascular resistance[13,39,77] that is normally overcompensated by sympathoadrenal stimulation.[13,78] The integrated hemodynamic response to acute hypercapnia is characterized by increased cardiac output and heart rate, unchanged or increased stroke volume, and decreased systemic vascular resistance.[13,20,77,79] Increased arterial blood pressure often accompanies acute hypercapnia[78] and cardiac arrhythmias sometimes may occur.[39] Acute respiratory acidosis can cause pulmonary hypertension[79] and may potentiate the effects of hypoxic pulmonary vasoconstriction.[13,39] In patients with inadequate or blocked sympathetic response (or impaired myocardial function), acute hypercapnia can result in hypotension.[13,39] Therefore, careful attention to hemodynamic monitoring is indicated when hypercapnia is induced, especially in patients with known cardiovascular disease. The hemodynamic response to acute hypercapnia generally subsides spontaneously after 36 hours, with the compensation of respiratory acidosis.[79] In patients with ARDS, myocardial depression that develops during permissive hypercapnia can be attenuated rapidly with the administration of THAM.[77]

All currently used sedatives will exacerbate hemodynamic instability in the presence of hypovolemia,[61] so a patient's fluid status should be evaluated prior to implementing low V_T ventilation. Critically-ill patients often require anesthetic doses of narcotics (or high levels of benzodiazepines), so hypotension is common even in the

presence of normovolemia.[80] Administering narcotics in combination with benzodiazepines and neuromuscular blocking agents further increases the likelihood of hypotension.[80] Hypotension is common with the use of midazolam and propofol,[61,81] but occurs more frequently with propofol.[82] High doses of morphine, meperidine, or alfentanyl may cause hypotension with either tachycardia or bradycardia.[80] The hypotensive effects of morphine can be prevented by pretreatment with H_1 and H_2 blockers.[80] Fentanyl may be particularly advantageous because it has less hemodynamic effect for a given level of analgesia.[80] In addition, using continuous infusions rather than intermittent boluses of narcotics and/or benzodiazepines may produce less hypotension and a more consistent level of sedation.[61,80,81] Among neuromuscular blocking agents, pancuronium may cause hypotension and tachycardia, whereas vecuronium and atracurium are least likely to have adverse hemodynamics effects.[80]

Pulmonary Hygiene

Increased lung volume is considered crucial to pulmonary hygiene.[83] Transient hyperinflation is generally believed to promote secretion clearance by increasing the expiratory flow from a higher end-inspiratory volume.[83,84] Therefore, using low V_T ventilation in ALI or ARDS without providing for transient hyperinflation may increase the risk of retained secretions. A case of multi-lobar lung collapse from mucus plugging has recently been reported in a patient managed with low V_T ventilation, despite 22 cm H_2O of PEEP.[85] The potential risk of retained secretions should raise awareness regarding the adequacy of airway humidification and pulmonary hygiene practices during low V_T ventilation in ALI or ARDS. Adjunctive therapies such as use of sigh breaths with suctioning or chest physical therapy should be considered when thick secretions occur during low V_T ventilation.

Discontinuation of Mechanical Ventilation

Several prospective studies have found that applying a systematic protocol for discontinuation of mechanical ventilation yields better outcomes than are achieved by relying on physician judgment alone.[86–89] The ARDS Network protocol is consistent with that objective. PS was chosen as the weaning mode because the pressure level can be titrated to partially unload the respiratory muscles and promote graded muscle reconditioning.[90,91] Excessive reduction in patient WOB can be identified by changes in the ventilatory pattern (increased V_T and decreased f).[90,92] The highest PS level allowed by the protocol (20 cm H_2O) coincides with a level reported to generally reduce patient WOB to normal.[91,93]

A potential problem with the PS weaning protocol occurs when clinicians steadfastly associate tachypnea with impending failure. During the ARDS Network study, we encountered a reluctance among some clinicians to aggressively wean down the PS level when patients exhibited tachypnea (f of 26–35 breaths/min). In patients recovering from ARDS, the elastic WOB often is increased, so rapid shallow breathing may represent an adaptive mechanism to maintain V_E while reducing energy expenditure.[94] Tachypnea by itself may not be a reliable indicator of WOB[95] or it may indicate excessive imposed WOB that can be corrected with extubation.[96] In one study, tachypnea ($f > 40$ breaths/min) spontaneously resolved 18 hours after extubation.[96] Assessment of tolerance is an important aspect of the ARDS Network weaning protocol (see Table 3). Pronounced accessory muscle use[93] or a breathing pattern exhibiting persistent respiratory alternans and abdominal paradox[97] may indicate impending diaphragmatic fatigue. Tachypnea in the absence of other signs of intolerance should not impede weaning in patients recovering from ALI or ARDS.

In Conclusion

We have described how to use the National Heart, Lung, and Blood Institute's ARDS Network low V_T protocol to manage patients with ALI or ARDS. Important issues such as early assessment of a patient's fluid and cardiovascular status, sedation, correction of acidosis, and pulmonary hygiene have been discussed. In brief, dyspnea and patient-ventilator discoordination commonly occur, and increased sedation will probably be required in order achieve patient comfort, V_T, and P_{plat} goals. A review of the literature suggests that respiratory acidosis and hypercapnia are not severe in most patients and therefore should not be an impediment to using the low V_T ventilation protocol. For more information, the reader is directed to the National Heart, Lung, and Blood Institute's ARDS Network web site at: http://hedwig.mgh.harvard.edu/ardsnet.

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Appendix

Measurement of Ventilator Circuit Compliance and Calculation of Delivered Tidal Volume

1. Connect the circuit hosing and humidifier (when appropriate) to the ventilator.

2. Make the following adjustments to the ventilator:

   - Set *f* (respiratory rate) = 6 breaths/min
   - Set V_T (tidal volume) = 50 mL
   - Set PEEP (positive end-expiratory pressure) = 0 cm H_2O
   - Set the end-inspiratory pause at 1 s
   - Use any inspiratory flow rate

3. Occlude the stem of the Y-piece connector either with a cork or with the palm of one hand, grasped tightly.

4. Measure the inspiratory plateau pressure (P_{plat}).

5. Increase V_T in 50 mL increments and re-measure P_{plat} until $P_{plat} = 50 \pm 5$ cm H_2O.

6. Calculate the compliance of the ventilator circuit as V_T / P_{plat}

7. The compliance of the ventilator circuit can be rounded-off to the nearest whole number.

When more than one type of ventilator circuit is used (ie, disposable versus non-disposable, heated-wire versus non heated-wire) or if humidifiers are used only in a select group of patients, then recalculate the ventilator circuit compliance under all conditions. With disposable circuits used with a humidifier, and when heated-wire circuits are used, it is advisable to measure the compliance after the circuit has been heated to clinical conditions for several hours, in order to evaluate the effect of temperature on circuit pliability.

Once the compliance of the ventilator circuit has been determined, the easiest way to adjust the V_T for compression volume loss is to set V_T for the protocol target and measure peak inspiratory pressure (minus PEEP) over several breaths to obtain an average. Multiply the average pressure by the ventilator circuit compliance to obtain the compression volume loss. Then add the compression volume loss to the set V_T. The average peak inspiratory pressure (minus PEEP) should be re-measured at the higher V_T to ensure that the compression volume has not markedly increased with the initial adjustment.

Decision Analysis for Large Capital Purchases: How to Buy a Ventilator

Robert L Chatburn RRT FAARC and Frank P Primiano Jr PhD MBA

Introduction
Justifying the Proposal
  Historical Perspective
  Current Situation Analysis
  Challenges
  Opportunities
Decision Analysis Procedure
  Screening
  Request for Proposal
  Initial Clinical Evaluation
  Cost Analysis
  Technical Evaluation
  Data Analysis
  Results
Purchase Recommendation
Discussion
  Control Scheme
  Operator Interface
  Alarms
Conclusions

We describe a formal decision-making procedure for purchasing intensive care ventilators. We adapted a general decision-making tool known as an additive, compensatory, multiattribute utility model. The model incorporates input from the various stakeholders in the decision. It identifies the factors that are important in the decision and the alternative decision options, weights the factors, ranks the alternative decisions on how well they serve the factors, and finally provides an overall score that identifies the best option. This model provides a more objective and analytical approach than is often used in purchasing decisions. The benefits include simplifying discussion among stakeholders and assisting administrators in justifying major purchase proposals. *Key words: decision analysis, purchasing, ventilators.* [Respir Care 2001;46(10):1038–1053]

"Most of our daily experience goes before our senses and passes through our feelings like a hazy cloud that slightly moistens the environment but makes little difference to the growth of our understanding."

—Dr Thomas L Saaty

Introduction

The standard accounting approach to making large capital purchases involves the calculation of various financial indices. These may include such items as return on investment, project payback period, and net present value of cash flow, among others.[1] But in hospitals, most department directors (and particularly respiratory care depart-

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Robert L Chatburn RRT FAARC and Frank P Primiano Jr PhD MBA have propriety interests in the product referred to in the Appendix. Robert L Chatburn RRT FAARC is a consultant to Amethyst Research LLC. Frank P Primiano Jr PhD MBA is a co-principal of Amethyst Research LLC.

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ment directors) do not have formal business administration training. Therefore, they may not be familiar with the routine tools used to justify project costs. More often, large capital purchases for patient care equipment are based on subjective impressions gained during short trial periods and product in-services provided by the manufacturers. This approach is suitable for many types of equipment in which the features are fairly obvious and the cost is under a few thousand dollars. Mechanical ventilators, however, are different. They are relatively expensive ($10,000 to $30,000) and so complex that only a small fraction of their capabilities can be observed during even a prolonged trial period of actual patient care. This is especially true in the case of a newly introduced machine or one that is new to the department personnel.

When evaluating several complex alternatives, it is helpful to use a systematic approach to decision-making. The process can be fairly complicated if there are many factors to consider that combine in different ways to create various outcomes. For example, in choosing a ventilator we would like to rank several alternative choices on various characteristics (eg, cost and technical features), each with its own arbitrary measurement scale (eg, present value and user satisfaction scores). We would also like to weight the relative contribution of each characteristic to the overall decision (eg, purchase price might be more important than user preference for alarm features).

Herein we present one approach for selecting the best of several alternative actions. We employ a formal structure[2,3] that makes explicit both the factors that are considered important in the decision and how important they are considered to be. This is accomplished by assigning a subjective weight to each factor. The factors can be either objective (eg, cost) or subjective (eg, ease of use), but their relative importance and how the choice measures up to them must all be quantifiable in some way. A simple mathematical analysis is applied that results in a (utility) score for each alternative action. The alternative with the highest score is then the recommended choice. To illustrate the process, we will use the example of purchasing a mechanical ventilator suitable for use in a hospital intensive care unit (ICU). We provide a step-by-step procedure for creating a capital purchase plan, along with a template for comparing ventilator brands. This example is based on an actual capital budget proposal we developed at University Hospitals of Cleveland. We refer to the ventilators as A, B, or C instead of using their real names, because the particular cost data and factor-weighting scheme we used may differ from that used by others, and we do not mean to suggest that the ventilator most appropriate for our situation should be a universal solution.

Justifying the Proposal

Historical Perspective

University Hospitals of Cleveland is a large tertiary care hospital in an academic environment. The respiratory care department serves neonatal, pediatric, and adult ICUs, with an inventory of 92 mechanical ventilators. An examination of this inventory showed that our department had a large proportion of outdated equipment. However, to justify a capital replacement purchase on the order of a million dollars requires more than a suggestion that newer equipment is desirable. Senior management and physicians alike needed to be briefed on the status of the department's current technical capabilities. To do this properly requires some historical perspective. In the case of mechanical ventilators, we found it useful to describe the evolution of technical design in terms of generations. Mechanical ventilators have evolved through at least 5 generations of technical improvements in the last 40 years (Table 1). The list in Table 1, along with actual data from a capital equipment depreciation report and consideration of our departmental objectives justified the purchase of ventilators, as described below.

Current Situation Analysis

The department of respiratory care owns 92 mechanical ventilators, from 10 different manufacturers. Grouped according to primary use, there are 31 adult ventilators, 26 pediatric ventilators, 31 neonatal ventilators, and 4 home care ventilators. All of the neonatal and pediatric ventilators are second and third generation. All but 2 of the neonatal ventilators are more than 12 years old. Of the pediatric ventilators, about half are 6 years old and the rest are over 12 years old. The adult ventilators are third generation. They range from 12 to 16 years old. The depreciable life span of a ventilator is 10 years. The time span between technologic generations is about 8 years.

Challenges

The age of our current inventory makes the availability and dependability of equipment uncertain, makes practicing state-of-the-art mechanical ventilation difficult, and makes some procedures impossible. There are several causes. First, ventilators are failing more frequently, which requires increasing expenditures of time and money for repairs, both in our department and in clinical engineering. Also, because these are life support systems, our liability in the event of failure during use is increasing.

Second, the fact that most of our ventilators are third generation (ie, are specialized for neonatal, pediatric, or

Table 1. The Technical Evolution of Mechanical Ventilators Expressed as Generations

Generation	Characteristics	Examples
1st	Simple electrical or pneumatic control circuits	Emerson Iron Lung, Bird Mark series, Emerson Post Op, Baby Bird
	Single mode operation	
	Primitive operator interface	
	Uncalibrated or coarsely calibrated dials, levers, aneroid pressure gauges	
	No alarms	
2nd	Simple analog electronic or fluidic control circuits	Bennett MA-1, Bourns BEAR 1, Ohio 550, Bourns BP-200
	On-off flow control	
	Restricted mode selection	
	Volume-controlled continuous mandatory ventilation	
	Pressure-controlled intermittent mandatory ventilation	
	Continuous positive airway pressure (CPAP)	
	Predominantly analog operator interface	
	Switches, knobs, aneroid pressure gauges	
	Basic machine alarms	
3rd	Digital (microprocessor) electronic control circuits	Puritan Bennett 7200, Siemens Servo 900, IntraSonics Infant Star
	Software updates possible	
	Proportional flow control to provide various waveforms	
	Expanded mode selection	
	Synchronized intermittent mandatory ventilation	
	Pressure support	
	Electronic operator interface	
	Light-emitting diode (LED) numeric and text displays	
	Electronic pressure gauge	
	Multi-purpose push buttons	
	Advanced machine alarms, system diagnostic messages, and patient status alarms	
4th	Computerized operator interface	BEAR 5, IntraSonics Adult Star, Dräger Babylog
	Cathode ray tube and liquid crystal displays	
	Text and graphic displays	
	Integrated waveform monitoring and calculated lung mechanics, extensive system diagnostics	
5th	Advanced control software and hardware	Hamilton Galileo, Dräger Evita 4, Puritan Bennett 840
	More accurate control of pressure, volume, and flow	
	One ventilator for neonatal, pediatric, and adult patients	
	"Virtual instrument" operator interface design	
	Easy upgrades through software rather than hardware	

adult patients) requires us to maintain an expanded inventory. This inflates capital investment and operating costs.

Third, there is an increasing body of evidence that the advanced control (eg, patient synchronization, dual control, automatic weaning, and lung-protective strategies) and monitoring capabilities of the fourth and especially fifth generation ventilators result in better outcomes.[4-6]

Fourth, the advent of inexpensive computing platforms has accelerated the development of new generations of ventilator technology. We need to update now and plan for future updates to keep pace with medical technology. It is no longer acceptable to use the same life support equipment for traditional depreciation periods and beyond.

Finally, because our department has been without staff development support for several years, training and continued competency have become major issues. Using 10 different designs of mechanical ventilator has made it impossible for all staff members (including the clinical engineering department staff) to gain expert experience on all systems. This restricts our ability to move staff among ICUs to accommodate census changes. We need to rely on the education support of vendors to keep our staff properly trained. But in order to assure the level of vendor support needed we must decide to use as few designs as possible and consolidate our purchases under 1 or 2 vendors, which reduces education requirements and leverages our purchasing power to motivate continued vendor participation in staff training.

Opportunities

A number of ventilator manufacturers have merged under large, multinational companies. This allows a high

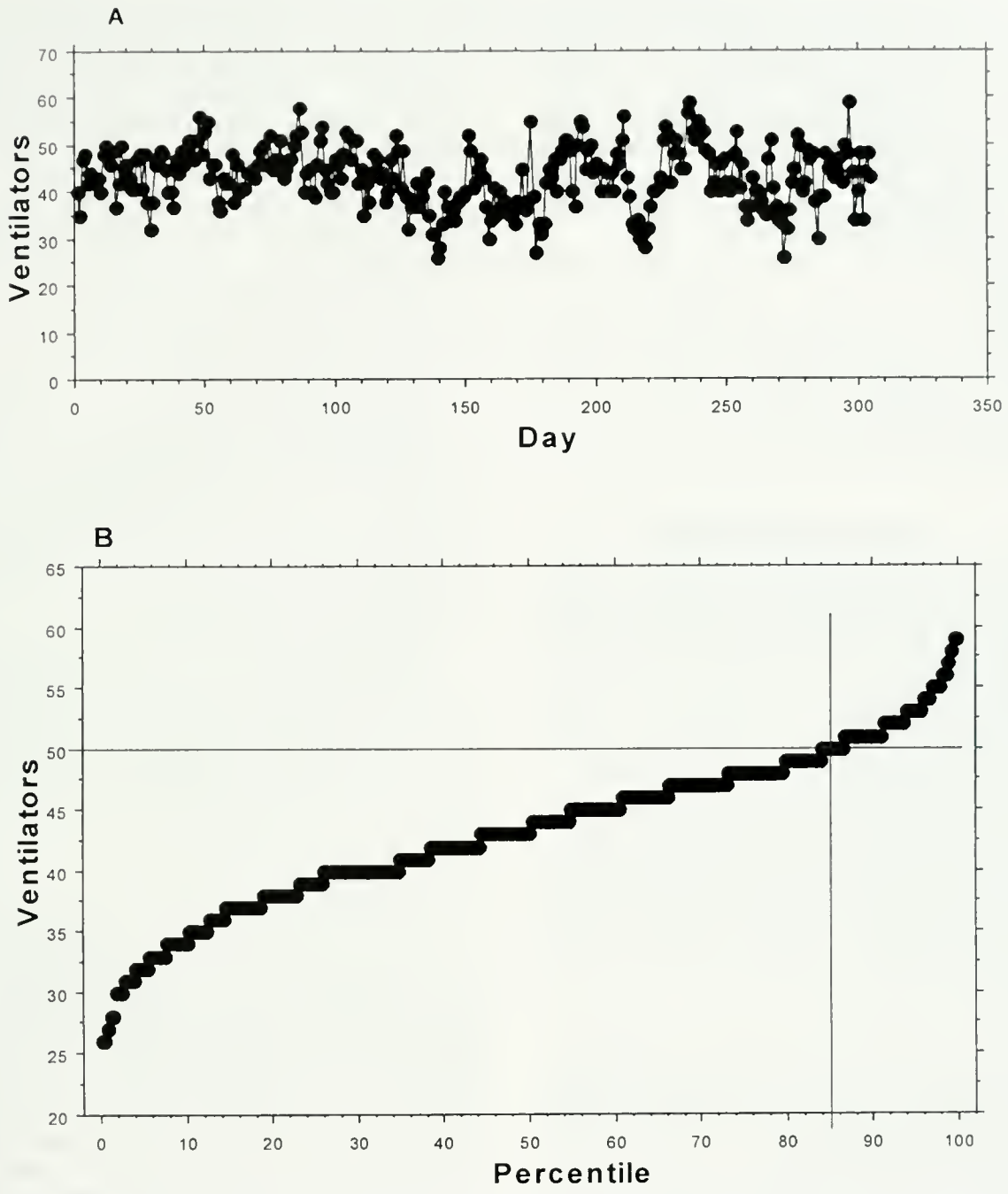

Fig. 1. Estimation of required new ventilator inventory based on graphic analysis of actual ventilator days in 1999. A: Daily ventilator use. B: Percentiles plot showing the percent of time (X axis) that a given number of ventilators (Y axis) were used. For example, the intersection of the thin lines indicates that 85% of the time we used ≤ 50 ventilators per day.

degree of vertical integration, so that any particular company can now provide sales and service for a full range of devices. This range includes neonatal, pediatric, and adult ICU ventilators, as well as home care ventilators. Mergers have also allowed these companies to offer more attractive pricing structures, at least while competitive conglomerates exist, because of the huge financial reserves of larger parent companies.

From a technical standpoint, the current leaders in ventilator manufacturing have developed or acquired ventilators that can function with every type of patient, rather than requiring different models for different populations.

This allows hospitals to carry a smaller inventory of ventilators and reduces maintenance expenses. It also simplifies training and helps to assure a more uniform skill level among more employees.

Some of the new ventilator designs are based on computerized control systems and operator interfaces. These allow upgrading to different versions primarily through software changes rather than hardware modifications, thereby potentially reducing future costs.

In summary, the goals of the purchase of new ventilators are to:

- Advance our patient care capabilities and increase staff competence
- Provide an appropriate technical platform for future updates and upgrades
- Reduce maintenance and rental costs
- Reduce capital inventory

Decision Analysis Procedure

Though all 92 of our current ventilators will need to be replaced in the next 5 years, we decided to begin by replacing just 50. This number of ventilators was selected on the basis of 2 facts:

1. It will replace the oldest ventilators used in the adult and pediatric ICUs.

2. Fifty ventilators will be enough to accommodate our daily patient load 85% of the time (Fig. 1).

Our selection process consisted of 7 phases: (1) application of screening criteria to narrow the number of alternatives, (2) request for proposal (RFP), (3) initial in-service and clinical use of a variety of new ventilators in the ICUs, (4) cost analysis, (5) technical evaluation, (6) data summary, (7) results reporting.

1. Screening

Initial screening criteria were used to limit this analysis to the most appropriate choices. The criteria included the following ventilator characteristics:

- Designed for intensive care use
- Ability to ventilate neonates, children, and adults
- Manufactured by a large, stable company with a good track record of service coverage in our area
- Supported by training materials and personnel supplied by the manufacturer
- Upgradeable primarily by software, without the need for hardware modifications

2. Request for Proposal

Once the vendors and their products were screened, we created an RFP that asked vendors to submit bids and plans to meet our specific needs. In this case we requested vendors to show not only how they could help us achieve our project goals but also to compare an asset management strategy (ie, vendor retains ownership of equipment but provides a just-in-time ventilator inventory and all maintenance needs) with a conventional capital purchase.

An RFP, as a formal, written proposal, helps to ensure that information is equally and fairly shared among all parties. It is useful to organize the RFP into specific sections,[7] including

- Questions regarding the company and product background
- Technical analyses (including comparison with other vendors' products)
- Customer support plans
- Training plans
- Strategies for implementing the changeover to new equipment
- Information management (eg, staff competency data, machine repair, and routine maintenance record keeping)
- Costs for consumables
- Maintenance and repair costs
- Any value-added services
- Purchase/lease prices, payment terms and conditions, delivery dates, warranties/return goods policies, etc

Vendors were invited to submit written responses to our RFP and also to make personal presentations. The presentations were helpful in answering questions and refining our requests.

3. Initial Clinical Evaluation

Demonstration units of current fifth-generation ventilators were provided to our department by the major vendors over the span of about 18 months. The purpose of this phase was to familiarize the staff with the technology and get some experience using the devices with patients. It also gave us a chance to judge the degree of customer support we might expect. Though the staff may have formed some opinions about ventilator performance, these were highly subjective, and the patient outcomes they remember anecdotally cannot be used as a basis for comparison of the ventilators. The availability of computerized ventilator simulations would have greatly decreased the time necessary for this phase by allowing staff to become familiar with the features and operating characteristics of a "virtual ventilator." Such simulations are just now becoming available (see the simulated Newport E100 ventilator at www.ventworld.com).

4. Cost Analysis

The University Hospitals of Cleveland purchasing department analyzed both capital purchase and lease data

Table 2. Financial Analysis Performed by the Hospital's Purchasing Department, Based on Vendor Bids, for the Purchase of 50 Ventilators

Ventilator Model	Cost* Each	Total Cost (with trade-in)	Warranty (y)	Annual Service Cost	Annual Lease Expense	Total 4-Year Cost	
						Own	Lease
A	29,398	1,282,429	3	143,500	1,066,143	1,425,929	4,264,572
B†	20,124	856,200	2.5	111,800	410,094	1,023,900	1,640,376
C	28,782	1,089,118	2	60,258	721,920	1,209,634	2,887,680

*All costs and expenses are in U.S. dollars
†3rd year limited warranty, parts only

from the manufacturers. Table 2 shows the results. The total 4-year cost to own includes full service maintenance agreements after warranties expire. The cost to own without service contracts is shown in the column titled "Total Cost (with trade-in)." We will trade in 52 of our current ventilators (based on age) for 50 new ventilators. As the new ventilators begin to be used in all areas and as the remaining older ones are retired over the next 3–5 years, we believe the total inventory of ventilators might be reduced by as much as 25% if we acquire equipment with the comprehensive capability to ventilate neonates, children, and adults.

The cost analysis shows that the lease or "asset management" option is much more expensive than capital purchase. Even with all the promised advantages of asset management (eg, continued training support, free upgrades, use tracking/adjustment), it is difficult to justify the greater expense over the life of the ventilator (10-year, straight line depreciation). Even for the least expensive option (Ventilator B) the lease cost would exceed the capital cost in a little over 2 years.

Regarding depreciation, it is clear that ventilators last longer than 10 years. It might seem fiscally prudent to keep a ventilator until its repair costs outweigh its replacement cost. However, our analysis of the evolution of ventilator technology (see Table 1) implies that the older the ventilator fleet is, the more likely it is that clinicians will not be able to provide the standard of care. Not meeting the standard of care could eventually lead to increased liability costs.

Operating costs are expected to be equivalent for all ventilators because they all use the same disposable patient circuit. Ventilators A and B, however, use flow sensors, the additional costs of which are difficult to estimate because we have no use data. Given our lack of experience with the new ventilators, the maintenance contract costs provide us with the best estimate of expected repair costs.

Note that our analysis of total cost to own was simplified to be just the sum of the expected capital and maintenance costs (after the warranties expired). However, if a more complicated arrangement is considered, whereby various payments are made over an extended period of time, then a true present value analysis should be performed (which would take into consideration inflation and interest data) along with a consideration of opportunity costs.[8,9]

5. Technical Evaluation

The technical evaluation of the candidate products considered previously published guidelines and descriptions.[10–12] Each vendor was requested to give a sales presentation and review his or her product's features. Then each ventilator was connected to a lung simulator and was available for testing for 1 week. A panel of reviewers was selected from the staff (1 physician from each ICU, 2 pediatric and 2 adult respiratory therapists from each shift, the administrative managers, a technician from clinical engineering, and the director of respiratory care). Each ICU was asked to select its own representative, and the supervisors from respiratory care selected the therapists. The clinical engineer who has historically been involved with our ventilator repairs was the natural selection from his department. At institutions in which nursing is very involved with ventilator management, it would be important to consider including them. The director of respiratory care approved the final list of reviewers.

The vendors assisted the reviewers in simulating ventilation scenarios to provide a means for comparing functionality and ease of use without the limitations imposed by actual patient treatment. Reviewers were given a checklist that provided a mechanism for quantifying specific desirable features for the data analysis phase (Figure 2). The checklist was specially prepared to identify key features and was organized in an outline format. The features were both clinically relevant (ie, might affect patient outcome or operator efficiency) and could potentially differentiate one model from another (see Discussion section below for detailed description). For example, waveform monitoring features were included because they affect ventilator management and because the models we examined varied in the types of features offered. On the other hand, the presence of pressure and flow-triggering was not included, because all ventilators had these features. Like-

Ventilator Evaluation Checklist

Instructions
Place a check mark for each characteristic present
- * signifies subjective ranking
- 2 for good
- 1 for adequate
- 0 for poor or not available

Reveiw Date _____

Reviewer Name _____

	Ventilator A	Ventilator B	Ventilator C	Comment
1. CONTROL SCHEME				
A. Trigger variables				
Optional	0	0	0	Can be triggered by optional signals (eg, trachel pressure)
B. Limit variables				
Adjustable pressure rise	1	1	1	Pressure ramp in pressure controlled modes (eg, pressure support)
Active exhalation valve	1	0	1	Spontaneous breath flow allowed during mandatory pressure limited breath
C. Cycle variables				
Adjustable flow cycle	0	1	1	Adjustable breath termination during pressure support
D. Modes (see reference 14)				
Hierchical set point control	1	1	0	Mandatory minute ventilation
Hierchical servo control	1	0	1	Volume assist and/or flow assist (eg, tube compensation)
Hierarchical dual control	1	1	0	Volume assured pressure support, pressure augment, etc
Adaptive dual control	0	1	0	Pressure regulated volume control, AutoFlow, Adaptive Support, etc
Backup ventilation*	2	1	1	Automatic switch to safe mode in event of system failure
Preoxigenation mode*	1	1	1	Temporary delivery of 100% oxyen &automatic return to preset value
E. Optional functions				
Leak compensation	1	0	0	Tidal volume and sensitivity automatically corrected for circuit leaks
Indirect calorimetry	0	0	0	Can perform metabolic measurements (with optional hardware)
Backup battery power*	1	1	1	Consider hours of full operation possible on battery power
Power failure behavior*	1	2	2	Smooth transition to battery power with alerts
Rank (% of perfect score)	*39%*	*36%*	*32%*	
2. OPERATOR INTERFACE				
A. Ease of Use				
Power-up procedure*	1	0	1	Consider time necessary and number of steps
User interface configurable	2	1	0	User can change look of controls and/or monitor displays
Steps from powerup to VC-CMV	1	3	2	Rank by minimum number of steps to set up mode (fastest = 3)
Steps from powerup to PS	2	3	1	Rank by minimum number of steps to set up mode (fastest = 3)
Screen brightness/clarity*	1	2	2	Easy to see displays at distance or in dimly lit room
Screen layout*	1	2	2	Words easy to read, absence of clutter

Fig. 2. Checklist used to evaluate and compare ventilator brands (ie, brands A, B, and C). VC-CMV = volume-controlled continuous mandatory ventilation. PS = pressure support. autoPEEP = intrinsic positive end-expiratory pressure. (Checklist continued on next page.)

wise, the availability of a touch screen was not included, because it is not clear that it is a specific advantage. It is interesting to note that, psychologically, a touch screen (eg, on the Puritan Bennett 840) seems more satisfying than a universal selector knob (eg, on the Hamilton Galileo) because it gives instant gratification when selecting a control. However, a touch screen may involve a greater number of steps to make a given ventilator change if care is not taken to avoid this in the design stage. In general, it seems to us that ventilator interface designs lag behind, say, computer operating system interfaces, in terms of human engineering sophistication.[13,14] Given that life support devices such as ventilators need rapid control access and status assessment during critical situations, it would be interesting to see research comparing the human engineering features of current machines.

Some ventilators have the capability to record and download ventilator settings, alarm events, and the like to an external database such as an electronic medical record. However, it is not clear that such data would improve patient care or caregiver efficiency. Nor do most hospitals have the information systems infrastructure to make collecting such data practical. Therefore, we chose not to include automatic record-keeping as a discriminating ventilator characteristic.

The checklist compared the ventilators in 3 major areas: control scheme, operator interface, and alarms. The checklists submitted by the review panel were summarized (ie,

	Ventilator A	Ventilator B	Ventilator C	
B. Controls				
Convenient placement*	1	1	2	Controls grouped logically and appropriate for mode
Desired controls available*	2	1	1	Control settings available for any desired adjustment (eg, inspiratory hold)
Intuitively obvious*	2	1	2	Unexpected results avoided (eg, minute ventilation changes tidal volume)
C. Waveform monitoring				
Waveform displays*	1	2	1	Consider number of variables displayed and clarity of layout
Graphic scaling*	2	2	1	Vertical and horizontal axes can be changed manually and/or automatically
Cursor	1	1	0	Movable cursor allows displays of digital values from waveform
Pre/post loops	1	1	0	Can superimpose loops to see change with time/treatment
D. Patient monitor				
Leak	1	1	0	Calculation of % leak (ie, inspired - expired volume)
Tracheal pressure waveform	1	0	0	Real or estimated tracheal pressure monitoring
autoPEEP reporting*	2	2	1	Estimation of inadvertent PEEP
Lung mechanics reporting*	2	2	1	Resistance, compliance, time constant, work, etc (insp /exp values)
Digital values configurable	1	1	0	Display of monitored values can be changed
Optional data analysis software	1	1	0	Ability to download and analyze monitored values
Trend reporting*	2	1	0	Graphs parameters over time
E. Optional signals				
Oximeter	1	0	0	Can accept input and display values from pulse oximeter
Capnometer	1	0	0	Can accept input and display values from capnometer
Rank (% of perfect score)	*68%*	*64%*	*39%*	
3. ALARMS				
Nuisance reduction scheme*	0	0	1	Specific software incorporated to reduce nuisance alarms
Alarm screen layout*	1	1	1	Words easy to read, absence of clutter
Default settings*	1	2	1	Default settings logically selected or user adjustable
Retains setting from last use	1	1	1	Alarm settings retained after power-down
Remote alarm option	1	1	1	Can attach a remote alarm device to ventilator
Adjustable alarm sounds	1	0	1	Operator can adjust alarm volume and/or pattern
Smart disconnect	1	1	1	Ventilator stops delivering flow when disconnect sensed
Alarm event log*	2	1	1	Alarm events are stored in memory
AutoPEEP alarm	0	1	0	Alarms if autoPEEP occurs
Rank (% of perfect score)	*44%*	*44%*	*44%*	

Fig 2. (continued).

average responses calculated) by the technical director of respiratory care. The summarized data were used in the final analysis with the decision-support software (see Fig. 2).

6. Data Analysis

The final selection was made using a Microsoft Excel (Microsoft, Redmond, Washington) spreadsheet based on a procedure described previously[15] and elaborated in more detail herein, in the Appendix. Briefly, several mutually exclusive factors and subfactors in the decision were identified and weighted according to their perceived importance in the final decision. Then the alternative ventilator models were ranked according to the factors. The software then computed a score for each alternative based on the degree that it met the desired factors and the relative importance of the factors (see Appendix). This approach to decision analysis is called an additive, compensatory, multiattribute utility model.[2,3] This model has received the most attention in the literature and has been the most widely applied of all multiattribute utility models. The term "compensatory" refers to the fact that a low value on some attributes can be compensated (or "traded off") for a high value on other attributes. A tradeoff is an expression of how much of one attribute a person would be willing to give up in order to obtain a specified gain in some other attribute.[3]

The ranking grid for this analysis is shown in Table 3, and the spreadsheet layout for the ranking grid is shown in Figure 3. Ventilator rankings on cost and technical features were based on quantitative data (ie, cost analysis and

		Ventilator								
		A			B			C		
Factor	Weight	SS	NTSS	FS	SS	NTSS	FS	SS	NTSS	FS
Cost	50%									
	TSS	61			72			67		
			0.31	15.25		0.36	18.00		0.34	16.75
Technical Features	30%									
Control Scheme	30%	11.70			10.80			9.60		
Operator Interface	55%	37.40			35.20			21.45		
Alarms	15%	6.60			6.60			6.60		
	TSS	55.70			52.60			37.65		
			0.38	11.54		0.36	10.89		0.26	7.74
Customer Service	20%									
Educational Support	66%	52.80			46.20			33.00		
Preventive Maintenance	34%	30.60			20.40			23.80		
	TSS	83.40			66.60			56.80		
			0.40	8.07		0.32	6.44		0.27	5.49
Total Weight	100%									
				Total Score	34.85		35.34			29.98

Fig. 3. Results grid. SS = subfactor score. TSS = total subfactor score. NTSS = normalized total subfactor score. FS = factor score. See Appendix for explanation of calculations.-

average scores from technical evaluation checklists submitted by review committee members). The technical director of the respiratory care department ranked customer service qualitatively with input from the clinical engineering department. A larger number for a rank meant the ventilator more closely met our needs. The higher ranking for Ventilator A on education support was based on the availability of a greater number and higher quality of training materials on specific aspects of ventilation. The greater ranking on preventive maintenance was based mainly on the availability of factory service (vs third-party repair contracts, which happened to be an advantage in our particular case but might not be in other cases), on the fact that the ventilator used fewer machine parts (presumably offering greater reliability and lower repair cost), and the fact that the ventilator was designed to give easier access to the serviceable areas.

Table 3. Ranking Grid*

Factor	Ventilator		
	A	B	C
Cost†	61	72	67
Technical features			
Control scheme	39	36	32
Operator interface	68	64	39
Alarms	44	44	44
Customer service‡			
Educational support	80	70	50
Preventive maintenance	90	60	70

*Rankings are based on financial analysis (cost), ventilator checklist (technical features), and director's analysis (customer service).

†Ventilators are ranked on total cost to own (see Table 2); cost normalized so high cost = low rank.

Ventilator A rank = 100 × {1 − [1425929/(1425929 + 1023900 + 1209634)]}

Ventilator B rank = 100 × {1 − [1023900/(1425929 + 1023900 + 1209634)]}

Ventilator C rank = 100 × {1 − [1209634/(1425929 + 1023900 + 1209634)]}

‡Ranking scale for customer service: 100 = ideal, 50 = average, 0 = worthless.

7. Results

The spreadsheet analysis generated the results matrix shown in Figure 4, the equations for which appear in Table 4. It is important to note that our factor-weighting scheme was designed to support our goals of advancing the standard of care and increasing staff skill level. If the ventilators were evenly ranked on technical features, then the least expensive device would be chosen. However, if price were related to features, then our decision would favor a higher technical level at moderate cost.

Weighting of the factors and subfactors is not straightforward. Improper weighting can negate the entire process. We attempted to assign weights *a priori* by consensus of the evaluation committee. However, our initial low weight on cost (25%) mandated the purchase of the most expensive ventilator that had only a slight technical advantage. When cost was weighted at 50%, the result seemed (to our senior vice president) a more reasonable tradeoff between cost and capability. An alternative approach is to not weight cost but rather to express the final result as a benefit/cost ratio[16] (see Conclusions section below). A more rigorous approach to assigning weights involves generating a matrix of pair-wise comparisons among the factors (using an arbitrary numeric scale where, say, 1 means equality and 9 means that one is extremely better than the

Ranking grid (numeric values)

	Ventilator		
Factor	A	B	C
Cost	61	72	67
Technical Features			
Control Scheme	39	36	32
Operator Interface	68	64	39
Alarms	44	44	44
Customer Service			
Educational Support	80	70	50
Preventive Maintenance	90	60	70

Results grid (numeric values)

		Ventilator								
		A			B			C		
Factor	Weight	SS	NTSS	FS	SS	NTSS	FS	SS	NTSS	FS
Cost	50%									
	TSS	61			72			67		
			0.31	15.25		0.36	18.00		0.34	16.75
Technical Features	30%									
Control Scheme	30%	11.70			10.80			9.60		
Operator Interface	55%	37.40			35.20			21.45		
Alarms	15%	6.60			6.60			6.60		
	TSS	55.70			52.60			37.65		
			0.38	11.45		0.36	10.81		0.26	7.74
Customer Service	20%									
Educational Support	66%	52.80			46.20			33.00		
Preventive Maintenance	34%	30.60			20.40			23.80		
	TSS	83.40			66.60			56.80		
			0.40	8.07		0.32	6.44		0.27	5.49
Total Weight	100%									
		Total Score		34.76			35.25			29.98

Ranking grid (cell labels)

	Ventilator		
Factor	A	B	C
Cost	A1	A2	A3
Technical Features			
Control Scheme	A2	B2	C1
Operator Interface	A3	B3	C3
Alarms	A4	B4	C4
Customer Service			
Educational Support	A5	B5	C5
Preventive Maintenance	A6	B6	C6

Results grid (cell labels)

		Ventilator								
		A			B			C		
Factor	Weight	SS	NTSS	FS	SS	NTSS	FS	SS	NTSS	FS
Cost	WC									
	TSS	A11			B11			C11		
			A12	A13		B12	B13		C12	C13
Technical Features	WTF									
Control Scheme	W2	A21			B21			C21		
Operator Interface	W3	A31			B31			C31		
Alarms	W4	A41			B41			C41		
	TSS	A51			B51			C51		
			A22	A23		B22	B23		C22	C23
Customer Service	WCS									
Educational Support	W5	A61			B61			C61		
Preventive Maintenance	W6	A71			B71			C71		
	TSS	A81			B81			C81		
			A32	A33		B32	B33		C23	C33
Total Weight	WTOT									
		Total Score		AT			BT			CT

Fig. 4. Spreadsheet layout for decision analysis. Call labeling (letter and number) is arbitrary and does not correspond to normal spreadsheet column and row designations. SS = subfactor score. TSS = total subfactor score. NTSS = normalized total subfactor score. FS = factor score. See Appendix for explanation of calculations.

Table 4. Equations for Spreadsheets Shown in Figure 4

Grid Equation*	Comment
A11 = A1	Total subfactor score (TSS) for cost. (For factors with no subfactors, TSS = factor rank × 1.0)
A21 = W2 × A2/100 A31 = W3 × A3/100 A41 = W4 × A4/100	Subfactor score (SS) for technical features: SS = subfactor weight (as a decimal) × subfactor rank
A51 = A21 + A31 + A41	Total subfactor score (TSS) for technical features
A61 = W5 × A5/100 A71 = W6 × A6/100	Subfactor score (SS) for customer service
A81 = A61 + A71/100	Total subfactor score (TSS) for customer service
A12 = A11/(A11 + B11 + C11) A22 = A51/(A51 + B51 + C51) A32 = A81/(A81 + B81 + C81)	NTSS: TSS normalized by the sum of all TSS in row
A13 = 100 × WC × A12 A23 = 100 × WTF × A22 A33 = 100 × WCS × A32	Factor score (FS): factor weight (as a percent) × NTSS
WTOT = WC + WTF + WCS	Total of weights (note: also, W21 + W31 + W41 = W61 + W71 = 100%)
AT = A13 + A23 + A33	Total score for Alternative A

Equations are shown for Alternative A. Use corresponding equations for other alternatives (ie, substitute alternative letter for A).
*A1 through C6 contain ranking data

other) and then calculating relative weights using eigen vectors.[16–18] The same approach can be applied to ranking the alternatives in the absence of an evaluation tool such as our ventilator checklist.

Purchase Recommendation

Based on this analysis, we recommended the purchase of Ventilator B. We further recommended that installation and implementation be completed within a 6 month period to optimize staff education. It might be more financially convenient to spread the purchase over 18–24 months, but that would severely impair training efforts. Staff would be forced to maintain competence on the many current ventilator brands as well as focus on the new model, making it difficult to get buy-in and commitment. A delayed implementation would negatively affect all of the goals stated in the background section.

Discussion

Managers often make business purchases with the same methods they use in their personal lives. That means their decisions are mainly influenced by the charisma of the sales person and the allure of the presentation, advertising, and packaging, rather than by any systematic analysis of relevant product features. Managers with extensive experience and good instincts seem to be successful with this approach, particularly when the purchase costs are relatively low and the equipment's use is relatively specialized (eg, laboratory equipment). In our case, the cost was huge and we needed to achieve consensus among a large number and wide variety of stakeholders. Furthermore, the stakeholders were accustomed to justifying purchases according to the unique needs of their specialty (ie, pediatric vs adult ICU areas) and at first resented any attempt to "standardize."

The technical analysis of the ventilators was a key component of our proposal. The checklist used to compare ventilator features was organized to match the standard ventilator classification system.[10] As such, it is applicable to any type of ventilator. However, the specific features for a given outline item might vary, depending on the type of patient population being served. For example, if we had wanted to evaluate transport ventilators, we would have had fewer items listed for comparison under modes, and there would be no category of "waveform monitoring" under operator interface. The specific rationales we used were as follows:

1. Control Scheme

a. Trigger variables. Because all ventilators had both pressure and flow-triggering, the only distinguishing feature was the ability to trigger on an optional external signal (eg, tracheal pressure). As it turned out, none of the ventilators we looked at offered this option.

b. Limit variables. All ventilators had pressure, volume, and flow limiting capabilities. What distinguished them was whether the pressure rise to the pressure limit could be adjusted. Also, not all had an "active exhalation valve," which allows spontaneous breaths to occur during a mandatory, pressure-limited breath.

c. Cycle variables. The only discriminating cycle variable was an adjustable breath termination for pressure support.

d. Modes. There has been a definite evolution in ventilator control schemes, which has led to many new modes, with various levels of sophistication. A detailed description of these control schemes and the features of ventilator modes has been presented elsewhere.[19]

e. Optional functions. Leak compensation was a distinguishing factor. All ventilators had battery backup power, but there were differences in how long it would last. One of the ventilators had what we felt were inadequate alerts when the regular alternating current power was removed during operation.

2. Operator Interface

a. Ease of use. Being essentially computers, the ventilators differed in the time it took to boot up. They also differed in the user-configurable display features. It was enlightening to count the number of steps required to go from power-up to a standard mode of ventilation such as volume-controlled continuous mandatory ventilation or pressure support. A step was defined as the movement of the hand from one control (or screen location) to another. If multiple changes could be made without moving the hand from a control, then a step was defined as selection of a parameter along with adjustment of the parameter value (eg, select tidal volume and adjust to 500 mL). Screen clarity and layout appeal were subjective assessments, and there was a fairly wide variation among ventilator brands.

b. Controls. The layout of controls was a subjective evaluation but seemed important to the staff.

c. Waveform monitoring. There was a great deal of variation among the ventilators on this feature. Waveform monitoring should be designed to facilitate bedside evaluation of the condition of the equipment and the patient, including comparison between 2 time periods (eg, pre- and post-bronchodilator flow volume loops).

d. Patient monitor. Because a leak (in the patient circuit, around the endotracheal tube, or through a chest tube) will affect the accuracy of lung mechanics calculations,[20] as well as affect gas exchange, it is important that the leak size be estimated and displayed. Trending of key parameters (particularly resistance and compliance) is important to gauge the effectiveness of lung-protective strategies and other therapeutic maneuvers.

e. Optional signals. Several parameters derived from noninvasively-measurable respiratory variables have gained increasing acceptance as indicators of patient status. Two that are becoming routine additions to ventilator displays (along with their associated waveforms) are arterial oxygen saturation (measured by pulse oximetry) and end-tidal CO_2 (measured by capnometry).

3. Alarms

A nuisance alarm reduction scheme is a sensible feature that was well thought out on one ventilator. Alarm screen layout and the appropriateness of default settings were subjective but important practical evaluations. Another very important feature for the bedside caregiver is the use of what might be called "smart disconnect" software algorithms. This means the ventilator senses that the patient has been disconnected and does not try to ventilate the room with a huge rush of gas and a lot of noise.

Features other than those we focused on exist, but our selection of these was based on our need to evaluate ICU ventilators. A decision-maker must include or eliminate from the checklist those features appropriate to the class of ventilators under consideration. Features unique to a particular member of a class can be included if their consideration would affect the member's ranking compared to the others.

Conclusions

The analytic approach to decision-making we used was very helpful in the discussion stage, in which panel members came together to achieve consensus. It forced relevant issues to be included in the dialogue and the priorities to be stated, while tending to avoid digressions along unproductive lines of discussion. The data collection form provided a mechanism by which stakeholders could contribute input into the final decision according to their experience. Meetings to brainstorm relevant product characteristics and weightings created a sense of ownership that is necessary to assure success in the implementation phase. Psychologically, the decision model gets stakeholder participation in a nondisruptive manner, leaving the discussion free to focus on each individual's considered judgment without having to defend the relevance of that judgment.

It was surprising to us that it was relatively easy to get consensus, across all users, on the ventilator that ranked highest on technical features. For example, clinicians in pediatric patient care areas typically view their equipment needs as being distinctly different from clinicians in adult care areas. The few people who dissented were not on the review panel. Their arguments tended to be simply statements of their preferences, without any specific rationale. Without a framework for making decisions, such statements could influence the final outcome in proportion to the perceived authority of the individual. Though that might not be a bad thing, it is certainly not a rational process.

We were not able to reach consensus on cost. The clinical staff felt that cost should be a minor factor, as our main goal was to improve our patient care capabilities. Our administrator was sympathetic with that view but was constrained by the available capital budget. Some felt that weighting cost was simply a way of forcing that factor to dominate the decision, which tended to cast suspicion on the whole process.

One way around this conundrum is to simply take cost out of the initial factor analysis and then account for it later in the form of a benefit/cost ratio.[16] For example, in Figure 4 we could weight cost at 0% (this removes it from consideration as a factor) and increase the weights of the remaining factors proportionally (ie, technical features = 60% and customer service = 40%). This results in final scores of: A = 39.20, B = 34.67, C = 26.13, which are used to quantify the "benefit" of each ventilator. Next, in Table 3, recalculate the cost ranks such that a low num-

ber reflects a low cost and a high number reflects a high cost (ie, the cost of each ventilator is simply expressed as a decimal percentage of the sum of the costs of the 3 ventilators). This results in cost ranks of A = 0.3897, B = 0.2798, C = 0.3305. Finally, evaluate the benefit/cost ratios:

- A = 39.20/0.39 = 101
- B = 34.67/0.28 = 123 *(best choice)*
- C = 26.13/0.33 = 79

The final decision has not changed using this method, but the differences among the alternative choices are greater, and it may be more intuitively satisfying. It avoids completely any argument about the relative importance of cost compared to the other factors and casts the final decision in a mathematical form that may be more familiar to health care workers who are used to thinking in terms of benefit/risk.

The formal procedure described here produces documentation that facilitates efficient and confident communication with upper administration. And it serves to record our rationale in the event that we need to review it in the future (eg, for similar additional purchases). Our proposal was just one of many competing for a portion of a limited capital budget. Because of the organized presentation of well-reasoned information inherent in the structured decision analysis, our proposal was judged by senior management more favorably than the usual, unsupported, narrative-style budget request. In fact, after reviewing the proposal, our senior vice president decided to initiate a system-wide analysis of ventilator purchase needs. Therefore, we did not make the purchase we recommended but are now considering a much larger purchase, involving 3 to 4 million dollars over the next 5 years for up to 9 of our system hospitals. We intend to use the same decision support process to achieve consensus among those hospitals that participate in the 5-year plan.

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Appendix

Purchase Decision-Making Analysis

The decision process described in this report employs a simplified decision model that logically translates your experience and intuitive thinking into quantitative measures of relative importance to the decision. The model requires that you identify the numerous factors and subfactors you consider important in deciding among available alternatives. It then reduces the consideration of these factors and subfactors to a formalized procedure that assigns a score to each factor for each alternative. The scores for all the factors are summed for each alternative to obtain the total score for that alternative. The alternative with the highest total score is designated the best choice.

Scores are calculated as the products of weights and ranks. Weights are normalized numerical values used to designate the relative importance of each factor with respect to all the other factors. The subfactors of each factor are also weighted relative to each other. Weights are normalized so that the sum of the weights of all the factors (or subfactors of a factor) add up to 1. Ranks are numerical values used to indicate how well each alternative choice satisfies a factor or subfactor.

The actual calculations of the scores for the alternatives are straightforward and can be set up and executed on a spreadsheet (see Figure 4). The real tasks are to choose the factors and subfactors, and to assign the weights and ranks. The choice of weights, by design, formalizes the decision-maker's biases about the factors that bear on the decision. Consequently, it can be used to steer the decision one way or another if the necessarily subjective process of deciding on the weights is not done as objectively as possible. Ranking the alternative choices with respect to the factors is also not straightforward. It requires a thorough understanding of each of the alternatives and the exercise of reasoned judgement in the interpretation of the opinions of the various stakeholders in the decision.

The Process

The following steps are involved in the formalized decision process:

1. Specify the (mutually exclusive) alternatives among which a choice must be made. This defines the decision to be made. Usually the number of alternatives should be narrowed to no more than 5, based on preliminary considerations before the formalized process is begun.

2. Choose the primary factors (also known as summary factors,* usually a maximum of 5) that influence the decision. A factor can have none, one, or more subfactors that apply to it.

3. Choose the subfactors (also known as detail factors*) if any, that relate to each primary factor. Usually a maximum of 5 subfactors is assigned to any one factor. In the "tree" model used here, there is only one level of subfactors. That is, a subfactor does not have any of its own subfactors below it. Note, however, that the Ventilator Evaluation Checklist we used does have sub-subfactors. For example, Trigger variables, Limit variables, and Cycle variables are sub-subfactors under the subfactor Control Scheme, under the factor Technical Features. We did not weight these sub-subfactors (ie, they were considered of equal importance).

*Chatburn RL. Systematic decision making. Midnight Engineering, Nov-Dec, 1990:68-76.

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Appendix
(Continued)

4. Choose the weight for each factor relative to the other factors. These weights must total 100% (eg, cells WC + WTF + WCS = 100% in Figure 4, results grid, cell labels). A zero weight for a factor means that the influence of that factor is eliminated from the decision.

5. For each factor, choose the weight for each of its subfactors relative to its other subfactors (eg, cells W2, W3, and W4 in Figure 4, results grid, cell labels). The weights for each group of subfactors must total 100%, and a zero weight for a subfactor means that the influence of that subfactor is eliminated from the decision.

6. Rank each of the alternatives chosen in step 1 (eg, on a scale of 0 to 100, but any scale could be chosen) relative to its ability to satisfy each subfactor (see ranking grid in Table 3, repeated in Figure 4).

   a. When assigning ranks for cost factors and subfactors, the present value of all payments to be made throughout the life of the alternative should be used. This can be obtained from your financial department or computed using payment information and the formula:[†]

$$PV = \sum_{n=0}^{N} \frac{PMT_n}{(1+i)^n}$$

   in which PV is the present value of a series of payments, PMT_n is the payment made at n years from now ($n = 0$ is the present year), and i is the interest rate.

   b. Usually a higher cost is less desirable than a lower cost and should deserve a lower rank. This means that we would not want to rank the alternatives according to their costs but, instead, would like to rank them in reverse order to their costs. One way to do this is, for each cost factor or subfactor, to divide the cost associated with each alternative by the sum of the costs for all alternatives. Then subtract this fraction from 1 and use the result as the rank. Consequently, the alternative with the highest cost fraction will have the smallest difference from 1 and, thus, the lowest rank, and so on (eg, cells A1, A2, and A3 in Figure 4).

   c. On the Ventilator Evaluation Checklist, we ranked each ventilator on the subfactors based on the percentage of perfect score. For example, the Control Scheme subfactor had 14 sub-subfactors, each of which could get a maximum score of 2. A perfect score on Control Scheme would be 2 x 14 = 28. Thus, the rank for a ventilator as a percentage of a perfect score was the ventilator's cumulative sub-subfactor score divided by 28.

7. Calculate the subfactor score (SS) for each subfactor by multiplying the subfactor's rank (eg, cells A3, B3, and C3 in Figure 4) by its weight (eg, W3 in Figure 4; thus, A31 = W3 × A3).

8. For each factor, add the subfactor scores for each alternative to get the total subfactor score (TSS) for that alternative (eg, cells A51 = A21 + A31 + A41).

[†]Barnett RA, Ziegler MR. Finite mathematics for management, life, and social sciences. 4th edition. San Francisco: Dellen Publishing, 1987:304-307.

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Appendix
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9. Add the TSS for each factor across the alternatives to get the sum of TSS for that factor (eg, A51 + B51 + C51 in Figure 4). For each factor, obtain the normalized TSS (NTSS) for each alternative by dividing that TSS by its associated sum of TSS (eg, A22 = A51/[A51 + B51 + C51] in Figure 4). This step is important to prevent some factors from having inappropriate influence on outcomes because of differences in their ranking scales. For example, the cost subfactor score turns out to be a small number (ie, a fraction) compared to the subfactor scores for technical features and customer service. This happens simply because of the way the rankings are scaled (cost 0–1, technical features 0–infinity, customer service 0–10). If the cost subfactor had not been normalized, its contribution to the total score for each ventilator would have been insignificantly small compared to that of the technical features and would not have reflected the desired 50% weighting.

10. Multiply the NTSS total by the weight of its corresponding primary factor to obtain the factor score (FS) for each alternative (eg, A23 = WTF × A22 in Figure 4).

11. Add the factor scores for each alternative to obtain the total score for that alternative (eg, AT = A13 + A23 + A33 in Figure 4). The alternative with the highest total score is designated the best choice.

A summary of the equations for all the cells in Figure 4 is given in Table 4. If the calculations are set up on a computerized spreadsheet, then it is straightforward to change the weights and ranks to test "what if" scenarios to see the effects of these changes on the decision. Different factors and subfactors can even be added or removed from consideration to evaluate their influences.

An Available Implementation

Constructing a spreadsheet for the decision calculations can be time-consuming and may be impossible if you do not have access to a spreadsheet program. A convenient alternative exists. A purchasing decision tool computer program, which contains a set of default factors and subfactors judged by us to be important in the purchase of mechanical ventilators, is available for purchase from Amethyst Research LLC at its Web site, Ventworld.com.

Letters

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Cardiogenic Triggering Observed in a Patient with Acute Respiratory Distress Syndrome

The trigger variable causes a ventilator to initiate a breath by a change in pressure, flow, or time. Flow-triggering has become popular because the initial work to trigger the ventilator is less than that needed during pressure-triggering. The ventilator may be triggered unintentionally if the sensitivity is set too high, a condition usually referred to as auto-triggering. Auto-triggering has been responsible for patient-ventilator asynchrony and increased work of breathing.

Recently, Imanaka et al reported auto-triggering caused by cardiogenic oscillation during flow-triggered ventilation.[1] The heart as it pumps creates changes in airway flow, airway pressure, and esophageal pressure. During systole, as the heart ejects the stroke volume, its volume decreases and it occupies less space in the cardiac fossa, causing an intrathoracic pressure change. Apparently, the lungs quickly respond and fill the void. In doing so, a small amount of air moves into the lungs. As a result of this minute air flow, the ventilator's flow sensitivity mechanism responds by initiating a breath, hence cardiogenic triggering. Imanaka reported that patients who experienced cardiogenic triggering were those with more dynamic hearts: they had larger cardiothoracic ratios, cardiac outputs, cardiac indexes, stroke volumes, and pulmonary artery occlusion pressures, and had lower systemic and pulmonary vascular resistances, respiratory system resistances, and respiratory system time constants than patients who did not have cardiogenic triggering.

Recently, cardiogenic triggering was observed in a patient in our surgical trauma intensive care unit. The patient was a 41-year-old male pedestrian who had been hit by a car. He suffered multiple abdominal organ lacerations and bone fractures. On admission, he was taken to the operating room for repair and stabilization of those injuries and was subsequently transferred to the surgical trauma intensive care unit, where he developed acute respiratory distress syndrome. His ventilatory management on the Siemens Servo 300 ventilator used flow-triggered ventilation in the pressure-regulated volume control mode. Sedation and analgesia were provided by lorazepam (Ativan) and morphine sulfate. Doxacurium (Nuromax) provided paralysis. Massive fluid and blood replacement were necessary to maintain organ perfusion and oxygen content. On the 16th hospital day, his ventilator parameters were: pressure regulated volume control, fraction of inspired oxygen 0.4, respiratory rate 16 breaths/min, tidal volume 650 mL (9 mL/kg ideal body weight), and positive end-expiratory pressure 13 cm H_2O. Resultant circuit pressures were: peak pressure 35 cm H_2O, mean airway pressure 26 cm H_2O, plateau pressure 34 cm H_2O, and static compliance 30.9 mL/cm H_2O. Hemodynamic values included: pulmonary artery pressure 44/24 mm Hg, central venous pressure 22 mm Hg, cardiac output 11.5 L/min, and cardiac index 5.8 L/min/m^2. Blood gas values were: pH 7.27, arterial partial pressure of carbon dioxide 50.6 mm Hg, arterial partial pressure of oxygen 100 mm Hg, HCO_3^- 23 mEq/L, and arterial saturation oxygen 97%. Though the ventilator rate was set to 16 breaths/min, the actual ventilator rate was 18–19 breaths/min, according to the ventilator's digital display. This was verified manually with a watch for 1 minute. The initial assumption was that the level of paralysis was insufficient, allowing the patient to flow-trigger.

On observation of the patient, I noticed that there was a definite oscillation of the chest wall and ventilator circuit with each heart beat, corresponding to the QRS complexes on the bedside monitor. In addition, I noticed a concurrent oscillation in the light-emitting diodes of the ventilator pressure manometer. Concluding that this cardiac activity was occasionally causing the ventilator to trigger, I changed the trigger sensitivity knob from the flow-triggering "green" zone (flow-triggering sensitivity of 1–3 L/min) to a –2.0 cm H_2O pressure trigger setting. The cardiogenic triggering disappeared.

It is useful to compare the present patient's physiologic status with Imanaka's auto-triggering group (Table 1).

Our patient's heart was even more dynamic than the average heart in Imanaka's auto-triggering group, lending support to the conclusion that what I observed was cardiogenic triggering.

There are 3 potential problems associated with cardiogenic triggering. First, because of the increased respiratory rate, hyperventilation may occur. I do not know if hyperventilation occurred in this patient's case, because an arterial blood gas sample was not drawn when cardiogenic triggering was recognized. Second, an increased respiratory rate and minute ventilation may cause dynamic hyperinflation (intrinsic positive end-expiratory pressure). The patient's minute volume was at most 12.3 L, which could cause intrinsic positive end-expiratory pressure, especially since the inspiration-expiration ratio was already 1.5:1. Third, since our patient had what appeared to be an increase in respiratory rate, it could have been concluded that he was ineffectively paralyzed, which would have led to unnecessary admin-

Table 1. Comparison of Pulmonary and Hemodynamic Variables in Our Patient With Those in Imanaka's Auto-Triggering Group*

Variable	Our Patient	Imanaka's Group*
C_{RS} (mL/cm H_2O)	31	49.4 ± 8.8
CO (L/min)	11.5	5.47 ± 1.49
CI (L/min/m^2)	5.8	3.38 ± 0.90
SV (mL)	117	60.0 ± 18.2
HR (beats/minute)	98	92.7 ± 12.2
MAP (mm Hg)	43	89.5 ± 11.9
PAP (mm Hg)	30.6	20.8 ± 5.7
CVP (mm Hg)	22	9.2 ± 2.8

*n = 23
C_{RS} = respiratory system compliance
CO = cardiac output
CI = cardiac index
SV = stroke volume
HR = heart rate
MAP = mean arterial pressure
PAP = pulmonary artery pressure
CVP = central venous pressure

istration of additional sedative and paralytic drugs.

Imanaka suggested 3 applicable methods to prevent or establish the presence of cardiogenic triggering.

First is proper flow trigger sensitivity setting. Flow sensitivity can be effective when set at > 1 L/min. So if cardiogenic triggering is evident at 1–2 L/min, the sensitivity can be decreased by setting it to 3–5 L/min while retaining the benefits of flow-triggering.

Second, the ventilator can be switched to pressure-triggering. For years, pressure-triggering at 1.0–2.0 cm H_2O has been used. This method worked in the patient I described, although he was paralyzed. Should the paralysis have metabolized, he would have been able to trigger the ventilator with a 2.0 cm H_2O effort.

Third, the ventilator's graphics can be checked. A cardiogenically triggered breath in the presence of a paralytic agent will appear before the expected time-triggered breath. In patients breathing spontaneously, a cardiogenic breath may cause patient-ventilator asynchrony. One might expect cardiogenic triggering in patients with very dynamic hearts, as described by Imanaka. Or, as I observed, when the patient's chest and the ventilator circuit move with each cardiac cycle, cardiogenic triggering may be present.

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A Useful Oxygen Dilution Formula

The formula that follows is one that I have used for years for the development and testing of respiratory devices using oxygen flow diluted with air. These devices include nebulizers, oxygen diluters, and blenders. This formula is very easy to remember and, as a result, may be more useful than the nomograms developed for similar calculations.

IMPORTANT NOTE: This calculation, though accurate based on the information plugged in concerning flow and concentration, does not in any way eliminate the need for conscientious monitoring of airway oxygen concentration, fraction of inspired oxygen, and blood oxygen levels. Furthermore, the use of vented masks and open systems may require very high flows to avoid overbreathing and the resulting reduction of fraction of inspired oxygen. These factors are beyond the scope of this formula, as it only addresses the oxygen concentrations in the original mixture.

Please keep in mind that this equation is a dilution formula. As such, it works for any type of mixing of oxygen and air, whether by entrainment or blending, and whether pressurized or not. For those purists among you, I present the derivation at the end. It is not necessary to follow the derivation, however, in order to use the formula. The constants in the equation are easy to remember because they are simply based on the percentage of oxygen in ambient air: 21%. The first equation is the easiest to remember and relates total flow (oxygen and air combined) to the actual final oxygen concentration and the oxygen flow.

$$TF = \frac{79 \times O_2 \text{ flow}}{\%\ O_2 - 21} \qquad (1)$$

In this formula, oxygen flow is the flow setting on the oxygen flowmeter and percentage oxygen is the actual oxygen percentage in the total flow (TF). Percentage oxygen can either be measured or read off of an entrainment dial. Of course, total flow will then be subject to whatever inaccuracies exist in percentage oxygen.

As an example of its use, assume that an air entrainment device is set up with a 5 L/min flow of oxygen, and that the resulting mixture, going to the patient, is measured at 35% oxygen. The resulting total flow would be:

$$\frac{79 \times 5\ \text{L/min}}{35 - 21} \tag{2}$$

This works out to a total flow of 28 L/min. Many blending devices, particularly entrainment devices, will not operate against a back pressure or resistance to flow. Using a spirometer to measure total flow, then, will change the total flow. This formula always works.

The formula can easily be restructured to yield the required oxygen flow to provide a desired total flow and oxygen percentage. Assume a set-up is required to provide 80 L/min of total flow at 30% oxygen. With a little algebra, the formula is rearranged as follows:

$$TF \times (\%\ O_2 - 21) = 79 \times O_2\ \text{flow} \tag{3}$$

$$O_2\ \text{flow} \times 79 = TF \times (\%\ O_2 - 21) \tag{4}$$

$$O_2\ \text{flow} = \frac{TF \times (\%\ O_2 - 21)}{79} \tag{5}$$

In this case, then, the required oxygen flow would be:

$$\frac{80\ \text{L/min} \times (30 - 21)}{79} \tag{6}$$

which equates to 9.1 L/min of oxygen flow.

Likewise, if the resulting oxygen percentage is desired, based on a known total flow and a known oxygen flow, then the formula can be rearranged again as follows:

$$TF \times (\%\ O_2 - 21) = 79 \times O_2\ \text{flow} \tag{7}$$

$$\%\ O_2 - 21 = \frac{79 \times O_2\ \text{flow}}{TF} \tag{8}$$

$$\%\ O_2 = \frac{79 \times O_2\ \text{flow}}{TF} + 21 \tag{9}$$

If we plug in the above values, we find that:

$$\%\ O_2 = \frac{79 \times 9.1}{80\ \text{L/min}} + 21 = 30\%. \tag{10}$$

That answer is, of course, consistent with the calculation above.

Please note that it is not necessary to do the algebra to change the formula. Using the first form of the formula, which is the easiest to remember, the numbers can simply be plugged in and the calculation done without rearranging the formula itself.

Derivation

The formula first stated is simply a combination of 2 rather obvious equations, based on the percentage of air that is oxygen (approximately 21%, at least within the accuracy required for our calculations). Flow meters and oxygen analyzers are rarely more accurate than the 2 significant figures we are using.

The first equation, then, simply states that the total flow is the total of the oxygen flow and the air flow:

$$TF = O_2\ \text{flow} + \text{air flow} \tag{11}$$

or

$$\text{Air flow} = TF - O_2\ \text{flow} \tag{12}$$

The second equation simply states that the oxygen percentage is made up of the oxygen flow and the oxygen in the air itself, divided by the total flow:

$$\%\ O_2 = 100 \times \frac{[O_2\ \text{flow} + 0.21\ (\text{air flow})]}{TF} \tag{13}$$

Next, we will take the equation for air flow above and plug it into the second equation for net oxygen, as follows:

$$\%\ O_2 = 100 \times \frac{]O_2\ \text{flow} + 0.21\ (TF - O_2\ \text{flow})]}{TF} \tag{14}$$

Then, a little algebraic rearranging yields the first formula:

$$\%\ O_2 = 100 \times \frac{[O_2\ \text{flow} + 0.21TF - (0.21 \times O_2\ \text{flow})]}{TF} \tag{15}$$

$$\%\ O_2 = \frac{79 \times O_2\ \text{flow} + 21TF}{TF} \tag{16}$$

$$TF \times \%\ O_2 - 21TF = 79 \times O_2\ \text{flow} \tag{17}$$

$$TF \times (\%\ O_2 - 21) = 79 \times O_2\ \text{flow} \tag{18}$$

or, finally:

$$TF = \frac{79 \times O_2\ \text{flow}}{\%\ O_2 - 21} \tag{19}$$

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Reviews of Books and Other Media. Note to publishers. Send review copies of books, films, tapes, and software to RESPIRATORY CARE, 600 Ninth Avenue, Suite 702, Seattle WA 98104

Books, Films, Tapes, & Software

The Multiskilled Respiratory Therapist: A Competency-Based Approach. David W Chang EdD RRT, Lisa Ramfjord Elstun RRT, and Arthur Pierson Jones EdD RRT. Philadelphia: FA Davis. 2000. Soft cover, illustrated, 240 pages, $29.95.

The self-declared intention of the authors of this monograph is to assist respiratory therapy students and graduate practitioners in developing additional knowledge and skills in areas that are beyond the scope of "mainline" respiratory therapist (RT) practice. This is perceived as a useful goal in order to enhance the value of the RT to the patient and to the multidisciplinary health care team. The book succeeds admirably in the realization of this goal.

Whether we RTs know it (and like it) or not, our profession has come under intense scrutiny in recent years, and this is a direct result of our own actions. About 10 years ago, the leaders of the American Association for Respiratory Care's voluntary sector, acting in concert with certain executive office staff, finally succeeded in persuading influential legislators that RTs were more than mere delegated caregivers. These lawmakers had been laboring under the misconception that RTs slavishly performed formulaic tasks that required virtually no discretion or judgment. Policymakers have now been made aware that the practice of respiratory care obliges RTs to acquire an extensive inventory of clinical assessment skills. Of course, the other side of that coin renders it imperative that managers develop a strategy whereby the skills base of each member of the staff is extended and refined. The content of **The Multiskilled Respiratory Therapist: A Competency-Based Approach** does an excellent job of defining the component elements of the skills inventory that constitutes the therapeutic armamentarium of the multiply competent RT. This volume enumerates the constituent elements of such clinical competencies as venipuncture, insertion of venous and arterial cannulae, hemodynamic and electrocardiographic monitoring, mechanical circulatory support, nocturnal oximetry/polysomnography, flexible fiberoptic bronchoscopy, pulmonary exercise rehabilitation, and respiratory care practice in alternative sites. A clear and unambiguous description of the requisite skills necessary for the mastery of each of these extended roles allows clinical preceptors to convey a clear picture of their expectations to prospective students, while also furnishing those preceptors with resources to assess the degree to which their junior colleagues have succeeded in mastering the material. In this manner, students need not guess or infer what the preceptor might be looking for, but are supplied with a detailed list of the skills that must be attained, taking the guesswork out of training for teacher and student alike. Each chapter incorporates learning objectives, an authoritative bibliography, study questions (with an answer key), and, where appropriate, a competency checklist. Hence, the acquisition of competencies cannot only be assessed, but documented as well—a task that has assumed enormous importance of late in the eyes of third-party surveyors such as the Joint Commission on Accreditation of Healthcare Organizations.

The monograph is handsome, richly illustrated with photographs and line drawings, and incorporates a useful index. I encountered only 9 typographic errors in the entire volume, an impressively low figure. The equation (on Page 92) for estimating mean arterial pressure lacks a set of parentheses; it should read: "MAP = [systolic + (diastolic × 2)]/3". The right-side leads are missing in Figure 7–4 (on Page 115) depicting the 12-lead ECG. And the formula (on Page 117) describing the "R to R Method" for calculating heart rate will actually yield a value for the cardiac *period*, the inverse of rate, rather than rate itself.

But these are minor criticisms when compared to the wealth of authoritative and comprehensive information presented in this volume. I enthusiastically recommend it to any respiratory care department manager who is seeking to extend the competencies of the RTs practicing in her/his department.

It is rather predictable that this monograph will be succeeded by a second edition. I would like to see any subsequent edition expanded to include some of the competencies considered to constitute mainline skills, in addition to the extended functions that form the subject of this edition. As a former manager of respiratory care departments on both coasts, I have come to realize that even graduates of elite respiratory therapy programs often have glaringly obvious gaps in certain clinical competencies that are considered fundamental baseline skills. To the extent that current-day caregivers might be found wanting with regard to routine assessment skills, our credibility as a profession is fated to suffer. Thus, a thoroughgoing monograph, in the style of the present volume, that enumerates the elements of commonly-encountered clinical assessment tasks (such as arterial blood gas interpretation, assessment of respiratory mechanics for mechanically ventilated patients, and discrimination between hypoventilation versus shunting versus ventilation/perfusion mismatching as an etiology for hypoxemia, to name a few) would be extremely valuable. In the meantime, the availability of a resource such as **The Multiskilled Respiratory Therapist** will assuredly go far toward consolidating the hard-earned position our profession has achieved in the eyes of our nontherapist clinical colleagues. The monograph would undoubtedly be a valuable addition to the libraries of nursing service instructors as well, to the extent that some of the clinical assessment tasks considered come to be introduced into the skills inventories of nursing practitioners.

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Entry Level Respiratory Therapist Exam Guide, 3rd edition. James R Sills MEd CPFT RRT and Sandra Hogan. St Louis: Mosby. 2000. Soft cover (with CD-ROM), illustrated, 398 pages, $44.95.

Respiratory Care Exam Review. Gary Persing RRT. Philadelphia: WB Saunders. Soft cover (with CD-ROM), illustrated, 250 pages, $47.95.

I have had the pleasure of examining two of the newest review books for National Board of Respiratory Care (NBRC) credentialing. I'll start with a brief description of the 2 books.

Sills' review book is specifically designed to help prepare for the CRT exam only. The introduction section tells a little about how the certification exams are constructed and even gives some tips for getting ready for

the test. It is helpful, but not quite as nice as a similar section found in Meyer's *Master Guide for Passing the Respiratory Care Credentialing Exams*.[1]

There is a pre-test practice exam in the Sills book that has a wonderful answer key to accompany it. It not only tells why the right answer is right but also why the wrong answer is wrong.

The main portion of the Sills text, which consists of 17 chapters covering content from the most recent NBRC job survey, follows the pre-test exam. It is organized exactly like the NBRC matrix itself, which helps ensure that one is covering every aspect of the matrix. This seems like an especially good idea for those who may be a bit more "linear" than most. Also, at the end of each chapter, there are self-study questions, complete with answers.

The nicest features of these chapters are the exam hints and the bibliographies. There is an average of 4–5 exam hints for every chapter—almost as handy as having one of those Kettering people sitting right next to you while you study. And the bibliographies seem to be very complete and updated. They are good to have in case you want to dig deeper into a particular subject. My one complaint is that page numbers were not included for any of the references.

Another feature of the Sills text is a CD-ROM that contains a computer-based post-test. The idea is to help get accustomed to taking an exam on a computer. It is fairly easy to load and use, and it's free.

Persing's text promises to help both the CRT and the RRT in their studies. There's not much of an introduction—no muss, no fuss, just get on with the studying. There are also 17 chapters in Persing's book, again based on the most recent job survey; same as Sills. In fact, the topics are very similar to the Sills text. What's the difference? Persing's book has an extra chapter on neonatal/pediatrics, whereas the Sills book spends 2 chapters on airway management (compared to the 1 chapter offered by Persing).

Persing's chapters are organized in a manner similar to the curriculum of a respiratory program. It is an organization that might be more familiar to students who are still in a program, and it might make it easier for educators to implement in their own curricula. Also, each chapter has both pre-test questions and post-chapter questions—again, a concept not at all unfamiliar to respiratory students. There are exam hints, but not nearly as many as in the Sills text.

And, yes, there is a "Free CD Inside!" Apparently, this CD and Sills's CD were made by the same company—Brownstone Research Group. I checked to see if they had the same questions, but I was unable to locate any repeats. Persing's CD not only had the CRT exam, but also the RRT written exam and the RRT clinical simulations. As far as I could tell, they were reasonably close to NBRC's computerized versions.

Comparing Sills's and Persing's texts is a little like comparing apples to oranges. Sills's review book is geared specifically toward the CRT exam, whereas Persing's book is directed to both the CRT exams and the RRT exams. Thus, Sills offers more information about any particular topic and Persing provides a more broad-based but less detailed approach to each topic. For example, Sills spent an average of almost 20 pages on a subject, whereas Persing spent an average of only 10 pages. Similarly, Sills provides, on average, about twice as many pictures per subject as Persing, although I must say I did enjoy Persing's illustrations.

Still, I don't consider these to reflect differences in quality as much as differences in purpose. Persing's is the type of book that I as an educator would use to guide a class designed to prepare a student for graduation. For one thing, it is organized like a respiratory program curriculum. And because we are still in a classroom situation, we have plenty of resources to mix in with the review book to make a decent review class. This is in fact what I intend to do during this coming fall semester. About an hour or two will be spent each week helping the students put their learning into a format that will be easier to access when it comes time to study for the NBRC exams. Persing's book seems ideally suited toward that end.

The Sills book, on the other hand, seems better suited toward the graduate. Perhaps the graduate has not had the opportunity to organize her myriad reams of notes sufficiently. Or maybe she simply needs a fresh perspective on the material to be tested. I would suggest the Sills review book in situations such as these. It also helps that Sills's book is organized exactly like the NBRC matrix. Knowing just how much my own students depend on objectives-based testing to guide their studying, this aspect of Sills's book should be a welcome feature for those who are going it alone.

A more meaningful comparison would be between Sills's text and Wojciechowski's review guides,[2] since they both offer 2 texts, one for each exam. Similarly, Persing's text and Meyer's *Master Guide* are single texts that purport to prepare you for both exams and probably ought to be compared to each other.

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Pathology for the Health-Related Professions, 2nd edition. Ivan Damjanov MD PhD. Philadelphia: WB Saunders. 2000. Soft cover, illustrated, 545 pages, $27.

The study of the human body is part of nearly all of today's health-related professions. Individuals wishing to pursue careers in these professions receive training in biology, human anatomy, chemistry, and more during their pursuit of the various degrees and certifications. A course in the study of pathology is more often than not included in the training of these professionals. This book is designed to aid in teaching the basics of pathology while also providing numerous clinical examples to help the reader connect the presented facts to clinical situations. The intended audience is students enrolled in programs such as respiratory therapy, nursing, radiation technology, and others being introduced to the world of pathology for perhaps the first time. The book is well suited for that purpose. Individuals whose professions require advanced training in pathology, such as physicians and laboratory assistants, will find the book much less useful.

The book is divided into 23 chapters and includes a table of contents, index, and glossary. In addition, an outline is provided at the beginning of each chapter along with specific learning objectives, key terms, and concepts. Each chapter also contains numerous illustrations, pictures, tables, and graphs. The inclusion of numerous "Did You Know?" informational inserts throughout

the chapters helps to make reading the text a pleasant experience. These inserts contain information related, although sometimes indirectly, to the chapter. Oftentimes, as is the case of the "Did You Know?" insert on page 202, these inserts provide little if any useful information in regards to the specific learning objectives for the chapter, but instead act as an interesting break for the reader.

Each chapter focuses on a specific anatomic system and is organized in a uniform manner, with the learning objectives, key terms, concepts, and chapter outline beginning the chapter. Next, a brief but well constructed review of the normal anatomy and physiology of the body system is presented. A clear and concise review then follows of the etiology, pathology, and clinical features of the most commonly encountered diseases in today's health care settings. The chapter ends with a list of review questions to enable the reader to check his comprehension of the material presented.

The book's usefulness as a resource for practicing health care professionals is somewhat limited. Though a large number of diseases and pathologic conditions are covered, space limitations have prevented the author from spending more than a few pages on each condition. Health care professionals seeking an in-depth study on a particular disease will not find the book useful. However, if all that is needed is a concise overview along with the basic information on the disease, this book serves that purpose. For example, the information provided on amyotrophic lateral sclerosis totals 4 paragraphs. Though this certainly does not provide a lot of detail regarding the disease, it does provide basic pathology and clinical information on the disease.

The book is beautifully illustrated. The author obviously believes in the value of clear and colorful illustrations to assist in the learning process. The photographs of various diseased tissues help the reader relate the text and illustrations to real life clinical situations. In addition, colors are effectively used to organize items such as tables and graphics and to separate the topics within each chapter.

The book's narrative is straightforward and easy to comprehend. Very often texts are written at a level that makes it too difficult for the average reader to comprehend, but this is certainly not the case here. The author goes to great lengths to organize each chapter's information and then systematically presents the material in a concise and easy-to-understand manner. The presentation of the respiratory system (Chapter 8) covers a great deal of information and does so in a way that the reader never feels overwhelmed. This skillful economy of presentation occurs again and again throughout the book.

Ivan Damjanov's **Pathology for the Health Related Professions**, 2nd edition, provides a valuable resource for students in health-related programs of study. The book is well indexed, beautifully illustrated, and extremely well organized. The author has achieved his goal of providing a resource that presents difficult material in a way that allows the student to see the clinical usefulness of the material presented.

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Basic Mathematics for the Health-Related Professions. Lorraine J Doucette MS MT CLS. Philadelphia: WB Saunders, 2000. Soft cover, illustrated, 332 pages, $52.

A successful career in most of the health professions depends on a solid grounding in mathematics and science. However, many practitioners who enter health professions do so out of a desire to engage in patient care, not because of a primary interest in the aforementioned course work. The author dedicates this book "to all those health care professionals who struggle with mathematics. May this book help you painlessly solve health-related mathematics problems." I often work with students and graduate health care professionals who have survived mathematics courses, as well as health care programs, yet continue to be mathphobic. Indeed, both students and practitioners may benefit from a book such as this.

The book is thoughtfully organized into 3 sections and 15 chapters. The initial section begins with 6 practice tests to evaluate mathematics competency. The practice tests essentially parallel the content of the book. Each chapter includes a list of objectives, a review of pertinent mathematics principles, several example problems, and practice problems for the user to complete. Answers to the practice problems are included at the end of the book. Generous use of figures and tables, and some cute cartoons, enhance the text. The book is well edited, and there are few typographic errors.

The first chapter covers basic mathematical principles, including arithmetic, working with negative numbers, and rules for rounding numbers. Chapter 2 reviews significant figures, exponents, and scientific notation. The third chapter deals with fractions, decimals, and ratio and proportion calculations. Chapter 4 includes systems of measurement and unit conversions, including a thorough review of temperature scale conversion. Chapter 5 reviews dilutions and titers (primarily aimed at clinical laboratory functions), and Chapter 6 covers calculations associated with solutions. The second section (Chapters 7 and 8) reviews interpretation of medical orders and routes of drug administration. The author also applies ratio and proportion calculations as well as dimensional analysis to drug delivery. The third section, which is primarily geared toward clinical laboratory calculations, includes mathematics related to clinical chemistry, urinalysis, hematology, microbiology, basic statistical concepts, quality assurance/quality control, and instrument-method assessment.

The author provides several example problems in most chapters, and the correct answer for each example problem is printed in green for ease of identification. In keeping with the title, most of the example calculations are quite basic. Several of the examples in the drug administration chapter require the student to discover that 2 pills or half a pill must be given to deliver a certain milligram dose. It might be helpful in the second section if some more advanced calculations were included or if example calculations were more reflective of the complete calculation one must perform to deliver a drug dose. For example, rather than having the student simply calculate how many milligrams of drug one would give a 60 kg patient if the order were for 10 mg/kg, it would be instructive to also ask the student to determine how many milliliters of X% solution would be required to deliver that dose. Also, some of the wording is a bit confusing in this section, such as describing "concentration per minute" in a drip rate calculation, and a dose ordered in "mg/dL 3 times a day (tid)". A curiosity for me was that the author listed 3 routes of drug administration but did not include delivery via aerosol. These are minor criticisms, and an instructor could easily build upon the solid basis provided by the author.

The last section is directed at clinical laboratory personnel and appears at first glance

to have little connection with respiratory care. The information in this section is important for those who perform quality control measures in pulmonary function labs or with arterial blood gas analyzers. Practitioners who read the medical literature and have not had instruction in statistics would also benefit from reviewing pertinent chapters. This section includes the background and calculations for determining mean, median, and mode. A section on variance and standard deviation leads into a thorough treatment of Levey-Jennings charting. Topics such as sensitivity, specificity, precision, null and alternate hypotheses, *t* tests, and proficiency testing are also reviewed. As our profession increasingly emphasizes evidence-based medicine, it will be increasingly important for practitioners to understand and apply these concepts.

This book would be valuable in respiratory care programs that teach their own mathematics courses or to provide medical applications after a prerequisite mathematics course. For programs that teach a laboratory values course this reference would also provide insight into the derivation of lab data. Graduates may also find the book useful, since the author has organized pertinent content into separate chapters that can be used as desired. In a respiratory care environment that requires more mathematics ability than to simply decide how many unit dose containers must be delivered, this book could be a valuable resource.

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Cardiopulmonary Anatomy and Physiology. George H Hicks MS RRT. Philadelphia: WB Saunders. 2000. Soft cover, illustrated, 523 pages, $42.95.

Cardiopulmonary Anatomy and Physiology was "written with the allied health student, in particular, the respiratory care and nursing students in mind." The content and writing style is well suited to that intended audience and the book is well written and easy to read. The illustrations are excellent and make good use of color. The chapter topics are well selected and presented in a clear and concise manner. The presentation of cardiovascular and respiratory physiology is well balanced and in proportion to what would be expected for this type of book. I especially like the first chapter, which reviews the fundamental concepts of physics, chemistry, and biology needed to understand later physiologic concepts. The "Diagnostic Focus" and "Case Study Focus" sections integrated throughout the book emphasize the clinical relevance of basic physiologic principles. Each chapter ends with several self-study questions to test the reader's understanding of the physiology concepts outlined in the chapter. The questions are well written and the answers are in the back of the book. A student workbook with additional study questions would be a complement to this text, and the answers to those additional questions could be included in an instructor's guide rather than in the back of the text.

The section on cardiovascular anatomy and physiology (Chapters 2–8) covers the physiology concepts in a logical and orderly progression. Blood is a topic not often covered in enough depth by similar books, but this book does an excellent job. The section on respiratory physiology (Chapters 9–13) could be expanded a little. One suggestion would be a separate chapter on gas diffusion principles and diffusion of gases across the alveolar-capillary membrane. This topic is only covered briefly in Chapter 12, "Gas Exchange in the Lungs." Some of the basic renal physiology concepts are integrated into other chapters, especially the integration of cardiovascular control with renal physiology. However, I feel that the coverage of renal physiology and acid-base balance in Chapter 14 needs to be expanded to include more about the functioning of the kidneys under both normal and abnormal conditions. Chapter 15, on the control of breathing, is well written and includes the latest up-to-date information on that topic. The appendixes include sections on symbols and abbreviations used in physiology, formulas and equations, normal values, and pressure conversion factors.

I found the content of the text, tables, and illustrations of high quality, and I did not find any typographic errors. The only error I found was with the base excess equation listed on Page 422. The equation is not presented correctly. The term shown as "7.4pH" should be (7.4 – pH) and there appears to be a formatting problem with the equation, with regard to the brackets.

To summarize, I found this book well written and easy to read. Outside of the problem with the base excess equation mentioned above, I found the text, tables, and figures well-presented and factual, without any typographic errors. I can highly recommend this book as a text for a course in cardiopulmonary anatomy and physiology. The chapters on basic concepts and the blood are additional positives for this book, compared to others in this category.

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A Clinician's Guide to Tuberculosis. Michael D Iseman MD. Philadelphia: Lippincott Williams & Wilkins. 2000. Soft cover, illustrated, 460 pages, $59.95.

Imagine tuberculosis (TB), one of mankind's greatest scourges of the past, the present, and the foreseeable future, a disease that kills 2–3 million people each year, to be a big onion. The hard outer layers represent the tangible impacts of the disease on human individuals and society. This disease takes advantage of immune systems weakened by human immunodeficiency virus and other immunosuppressive conditions, and also of cultures crippled by poverty, historical neglect, and civil strife, to gradually suffocate and consume more children, working-age adults, and elderly persons than any other infectious disease. The inner core of the onion is full understanding of the disease and its elimination. The discovery and development of effective anti-TB antibiotics during and shortly after World War II provided us with effective tools to cut quickly through the outer layers of the onion, to cure, to prevent, and possibly even to eliminate this disease. However, in typical human fashion, the societies that developed those tools applied them almost exclusively in their own countries. Then, as local disease rates declined, those with the means lost their motivation. Scientific study of the disease, the development of new tools to fight it, and the public infrastructure to apply proven treatments were all severely curtailed. Unfortunately, since TB continued to thrive unabated in most of the world, outside the confines of the industrialized countries—those societies that in their self-serving short-sightedness had thought themselves to be approaching TB elimination—experienced a historic and dramatic resurgence of this disease in the late 1980s and early 1990s, which was reversed only by a relatively massive reinvestment of money and effort. This complicated story,

which continues to develop on a world scale, makes it clear to leaders in TB treatment and research, such as Michael Iseman, the Girard and Madeline Beno Chair in Mycobacterial Diseases at the National Jewish Medical and Research Center and Professor of Medicine at the University of Colorado School of Medicine in Denver, Colorado, that the eventual, effective path to TB elimination, the core of the onion, may lie as much through methodically continuing to peel each layer to learn the subtleties of the disease as through continuing to apply our currently available, more knife-like tools.

In **A Clinician's Guide to Tuberculosis**, Dr Iseman presents both routes to the core of this onion, and he does it in his own direct, tangible, and authoritative style, giving full respect and acknowledgement to works and workers of the past, present, and future. On each clinical issue he gives his educated opinion, with a well-referenced rationale. Practitioners using this book for a quick reference to help address a problem at hand will find these opinions to be useful adjuncts, and sometimes to be alternatives to the current "official" national guidelines. Researchers will find the presentations of current limitations of knowledge of aspects of TB and TB control, with extensive referencing and outlines, to be useful guides to important challenges and opportunities. Sections on new diagnostic tests, for example, list and discuss with great enthusiasm the many new tests that are available and under study; Dr Iseman states unequivocally which ones currently meet an adequate standard of proven clinical utility. Another beautiful example is the chapter on drug treatment. The British Medical Research Council, the United States Public Health Service and others have performed many meticulous, stepwise series of studies of various regimens of medical treatment for TB. Dr Iseman presents his own opinions of the findings and applications of those studies to contemporary treatment choices. He also assembles a tremendous table of 79 "selected short-course regimens," comparing their important features. The treatment chapter concludes with a 10-page historical discussion of directly observed therapy, and a strong argument in favor of its broader application.

One issue that will retain a high priority for medical staff, even as rates of disease decline in this country, is infection control. Dr Iseman's chapter on infection control is another example of his dual approach in his discussions. He has long been an advocate of effective and efficient means of preventing TB transmission, through means such as germicidal ultraviolet light, without incurring or imposing an excessive or dehumanizing cost and burden on health care workers and facilities. This section presents his approach, which may differ from the approach of some other authorities in the field, but his rationale is clear and well-referenced, allowing the reader to either accept the advice of this expert clinician or to read further, make comparisons, and reach his or her own conclusions.

One particularly effective passage in his epidemiology chapter is a 4-page section titled "New York City: A Case Study." In a classic example of his generosity in giving credit where it is due, he cites the 1988 report on TB in New York by Brudney and Dobkin as "one of the more significant studies in contemporary medicine." He outlines the early success of TB control efforts in New York City, then describes the demise of TB control and its catastrophic consequences. Furthermore, he points out how initially neither state nor federal governments helped the city until, in the early 1990s, "heroic (and expensive) measures bore fruit," with a dramatic reduction in both case rates and rates of the much-feared multidrug-resistant TB. It is especially refreshing and stimulating to see Dr Iseman give rhetorical emphasis to his main points: "A critical message from this saga is that the improvement occurred despite the continued human immunodeficiency/acquired immunodeficiency syndrome epidemic among TB-vulnerable subjects and ongoing immigration from areas endemic for TB. *The only real difference . . .* [being] *competent detection/treatment programs and improved infection control practices and facilities."* (Dr Iseman's italics.) That emphatic paragraph summarizes and outlines most of the book in both style and substance. The allusions are, on the one hand, to the medical, social, and political challenges to TB control, and on the other hand to the well-known and proven medical, social, and political means that effect TB control.

Somewhat surprisingly, Dr Iseman concludes his New York City case study with a note of almost despairing pessimism: "Rather than sustain high-quality programs until we might truly contemplate elimination, cuts will probably be made that will again unleash this destructive disease." He even quotes the German philosopher Hegel: ". . . people and governments never have learned anything from history. . . "

The allusion to Hegel, however, suggests that Iseman may believe in a Hegelian dialectic as-well, implying that the expression of optimism in describing the success of TB control in New York, along with his pessimism in expecting an imminent return to the failed policies of underfunding, may well be followed by a new synthesis of rational and effective, well-funded TB control. Dr Iseman challenges his readers not to accept his pessimistic antithesis, but rather to participate in the struggle to "sustain high-quality programs until we might truly contemplate [TB] elimination."

This is an idiosyncratic book, in which Dr Iseman displays many of his strengths as a preeminent leader in TB control. By writing the whole book himself, rather than following the more common approach of collecting and editing the works of a cast of experts, Dr Iseman can express his own opinions on a wide range of topics and can express them with his own personality. For example, after his preface and acknowledgements, he adds a poignant section entitled "Medical Knowledge: An Historical Process," which includes 2½ pages of quarter-page-sized photographs of five of his colleagues and heroes (Dr Leonid Heifits, Dr John Sbarbaro, Dr Wallace Fox, Dr Denis Mitchison, and Dr George Comstock), with brief vignettes about the contributions of each. It is wonderful but very unusual for the author of a medical textbook to present so vividly the giants on whose shoulders he stands. This book is one more contribution in a productive career devoted to a process that he states in this section is "like peeling an infinite onion: layer-by-layer we futilely seek the core of knowledge." Very consciously a medical historian, he accomplishes much more than an exercise in futility. He applies the "historical" lessons of the science and study of TB to contemporary problems in TB control, showing his readers how they can do likewise and accomplish a tremendous amount of effective, well-guided work, even without reaching a true core of perfect knowledge.

A Clinician's Guide to Tuberculosis delivers what it promises in both senses of the word. It is *by* a clinician—an expert clinician whose guidance, presented in this book, any practitioner would find useful in dealing with any level of TB control, from diagnosis and treatment to prioritizing research efforts, to designing public health policy. It

is also *for* the clinician—the practitioner in a public or private clinic who wants a contemporary and well-referenced manual. The book is written with tremendous passion and is an effective snapshot of the art and science of TB control at the beginning of the 21st century.

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Tuberculosis: A Comprehensive International Approach, 2nd edition. Lee B Reichman and Earl S Hershfield, editors. New York: Marcel Dekker. 2000. Hard cover, illustrated, 898 pages, $195.

The second edition of **Tuberculosis: A Comprehensive International Approach** is completely revised and expanded. It covers contents of various disciplines and dimensions relevant to broader emphasis on the control of tuberculosis (TB), declared by the World Health Organization (WHO) in 1993 a "global health emergency." The book's broad perspective on the subject suggests that the intended readership is not only all health care professionals engaged or interested in TB and its control, but also epidemiologists, public health planners, social scientists, economists, and national policy and decision-makers.

Part One, "Programmatic Background," comprises 5 chapters. The first chapter provides a historical perspective on TB and is an excellent introduction to the control aspect as well as to other specific topics in the book. The early attempt at an organized system to control the disease, accompanied by evolution of public health campaigns at the national level in several countries toward the end of the 19th century, leading to international organizations, appears to be the foretaste of the present global efforts in response to the resurgence of TB. In this first chapter, as well as in the rest of the book, certain shortcomings of the first edition have been redressed, such as omission of some important names of international experts and their works—notably, Sir Robert W Phillip of Edinburgh, who opened the first TB dispensary in the world to establish an organized system of TB control (page 19), and the British Medical Research Council, the pioneer in the model of the modern randomized clinical trial. Their early trials of anti-TB chemotherapy in India proved that domiciliary or ambulatory treatment could be as successful as sanatorium or hospital care (page 41, with photograph), with no difference between the proportion of contacts infected by exposure to segregated case and the proportion of those exposed to ambulatory case (page 58).

Chapters 2–5 summarize TB control, which on the global scale at present depends on the Directly Observed Treatment Short Course (DOTS) strategy recommended by the WHO, following the adoption of the framework for effective TB control developed by the International Union Against TB and Lung Disease (IUATLD). Programs in low-income and low-prevalence countries are described separately to clearly express their differences. The essential role of TB laboratories in the national TB control programs is emphasized (Chapter 4). Since 2 goals were proposed by WHO at the beginning of the 1990s to be achieved by 2000 (to cure at least 85% of smear-positive pulmonary TB cases and to detect at least 70% of existing infectious cases), Chapter 5 presents methods of evaluation of applied strategies of TB control in developing countries.

Because of the complex nature of TB, the book should be commended for inclusion of the basic aspects (Chapters 6–11). The highlight of Chapter 6 (on epidemiology) is the resurgence of TB in the United States and various factors concerning its cause, which include human immunodeficiency virus (HIV) infection, poverty, homelessness, drug abuse, immigration, and usually last, decreased funding for anti-TB efforts! On bacteriology, in addition to detecting and identifying *Mycobacterium tuberculosis* complex and non-TB mycobacteria, new methods are described on the direct detection of *M tuberculosis* by nucleic acid amplification—mycobacterial strain genotyping (Chapters 7, 9, 10, and 11), known as deoxyribonucleic acid fingerprinting, for tracing transmission of *M tuberculosis* in the community. On immunology (Chapter 8), progress toward understanding the immune response to mycobacteria, including HIV-*M tuberculosis* interactions, remains to be translated into practical advances relevant to TB control.

The next 3 parts of the book, namely, "Clinical Aspects" (Chapters 12–19), "Special Problems" (Chapters 21–23), and the first 3 chapters of Part Five, should be regarded as a crucial section in the main theme of the book. However, the integrated way they are presented (ie, specific subjects of clinical aspect interspersed with those of control aspects) should make them mutually understood by both clinicians and public health administrators. Chapter 12 on tuberculin testing is a much more expanded and detailed version of more recent studies. This is followed by subjects of case-finding and contact follow-up in high- and low-prevalence countries (Chapters 13–15), and again the role of restriction fragment length polymorphism or deoxyribonucleic acid fingerprinting testing as an epidemiologic tool is described. Chapter 14 stresses the process and role of diagnosis to identify and treat cases of active TB and latent infection in order to break the chain of transmission as current control strategies.

Chapter 16, on the treatment of TB, provides good detail on topics useful and practical in the settings of countries with high and low TB prevalence. Standard anti-TB treatment regimens and treatment for multi-drug-resistant TB in the United States, as different from the standard treatment regimens in resource-poor countries, developed by WHO and IUATLD, are described. Regarding adherence to treatment, the American Thoracic Society and the United States Center for Disease Control and Prevention, after having rejected universal DOT since 1960, finally recommended it in 1992 for universal use in the United States, following the increased evidence of patient noncompliance resulting in the outbreak of multi-drug-resistant TB (page 433); the DOTS strategy has been recommended by WHO for high-prevalence countries worldwide.

The next subject is the DOTS-Plus strategy (Chapter 17), the result of TB control workers in Peru and Haiti joining forces with the WHO Global TB Programme, Pan-American Health Organization, the United States Centers for Disease Control and Prevention, and IUATLD to create common cause in expanding DOTS that would take into account multi-drug-resistant TB. Since the end of 1998, when the DOTS-Plus strategy was set up, TB workers have realized that the projects are likely to rely on transnational technical, financial, and drug supply support. The last 2 chapters on clinical aspects concern treatment of latent TB infection (previously known as preventive therapy) (Chapter 8) and BCG (bacillus Calmette-Guerin) vaccines and vaccination (Chapter 19).

Part Four, "Special Problems," includes a chapter that mainly covers the relationship between TB and HIV infection and the implications of HIV on the TB control program. The chapter on TB in children (Chapter 21) touches on epidemiology, clinical aspects, and HIV-related TB. The last chapter (Chapter 22) of this part is quite useful in case management of DOT by the nurse case management model.

The first 3 chapters in Part Five, on unique aspects of TB control, identify 3 critical areas or "hot spots" in the program; namely, TB infection control to protect health care workers against the increasing risk of nosocomial TB infection (Chapter 23), TB in correctional facilities (Chapter 24), and TB among immigrants (Chapter 25).

The rest of the book, Chapters 26–34, are all new subjects expressing some key elements in the global concepts of TB control under development in international efforts, such as TB education and medical anthropology as an important adjunct to international TB control (Chapter 27 and 29). The need for coalition building for TB control at the national level to coordinate TB control efforts is exemplified by the Philippine experience (Chapter 26), whereas an example of political will to eliminate TB is expressed by the Singapore TB elimination program (Chapter 28).

The role of nongovernmental organizations (Chapter 30) is epitomized by the IUATLD, a federation of national TB and lung disease associations and individuals in 118 countries. In addition to TB control program development and direct assistance to Third World countries, the WHO's Global TB program DOTS strategy has been modeled after the programs developed by IUATLD. Other notable organizations include the American Lung Association, the Canadian Lung Association, and the Royal Netherlands TB Association.

The economic considerations of TB control (Chapter 31) have become crucial. Economic analysis results of costs and outcomes (ie, effectiveness and benefit in relation to specific points for TB control interventions) are used for epidemiology projections and analysis of future costs and savings. Though the impact of managed care on TB control, as part of the health sector reform in the United States, is described in Chapter 32, TB and communicable disease health officials are concerned regarding the ability of the private sector to maintain adequate community TB control efforts and to provide optimal patient management. Similarly, in developing countries there is currently a great deal of concern about the impact of reforms on TB control (Chapter 33). Chapter 34 describes the implementation of an advocacy and social mobilization strategy for TB, so as to create and sustain demands for DOTS in high-burden countries as the foremost priority in current efforts to control the global TB epidemic.

Finally, Chapter 35 speculates on the future of TB in the new millennium by reviewing remarkable changes during the past decade, both negative and positive, for discussion of the possibility of elimination of TB.

Overall, the two editors have ably achieved their aim of a "comprehensive international approach" appropriate for the subject of international control of TB. The book is well produced, with clear type-face, in hard cover, similar in shape but slightly bigger than the first edition. Tables, graphs, and photographs have been reproduced clearly. Up-to-date references appear at the end of each chapter. A useful index is provided, and typographic errors were minor.

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Say It in Spanish: A Guide for Health Care Professionals, 2nd edition. Esperanza Villanueva Joyce EdD CNS RN and Maria Elena Villanueva MD. Philadelphia: WB Saunders. 2000. Soft cover, illustrated, 425 pages, with 90 minute audio tape, $18.95.

Communicating with Spanish-speaking patients has been a challenge for many health care professionals. **Say It in Spanish** is geared to help health care providers communicate with patients who speak only Spanish. The authors have done a good job of keeping the focus on the intended audience. The book is formatted in a unique systematic approach, taking the reader from prehospital scenarios to patient admission and different departments within the hospital. The book is divided into 7 units and contains 40 chapters. Unit 1 deals with prehospital care through admission. Unit 2 has examples of various physician visits. Unit 3 is concerned with departments within the hospital, such as radiology. Unit 4 focuses on physical examination, greetings, and common expressions. Unit 5 gives basic vocabulary. Unit 6 emphasizes grammar. Unit 7 has general cultural information and home remedies. The authors explain how phrases are not always translated literally, but the most common Spanish words have been selected and presented. This is important for clinicians to understand so that they convey the right idea and not necessarily a word-for-word translation. The authors have done what they set out to do by providing the most common phrases and dialogue to assist the clinician in communicating with patients.

Dialogue examples are helpful to anticipate the patient's response and how to communicate with patients. Questions that elicit "yes" or "no" or short answers make communication easier.

I especially liked the audio tape included with the book. The tape is arranged to help the reader understand pronunciation and how words sound in the speed of normal dialogue. There are sections in the book and chapters organized from pre-hospital care to emergency department, and admission to a general floor care area. There is also a section on visit to family, doctor, dentist, cardiologist, and endocrinologist, to name a few. The book also covers specialty departments such laboratory, pharmacy, and radiology. There is a chapter on cultural differences, which explains that many Hispanics have certain beliefs toward treatment of illness. The appendix includes common phrases and enunciation in alphabetical order for quick reference. Based on my limited knowledge of written Spanish, most of the grammatical structures appeared correct. However, I did use a dictionary to double-check more complicated sentence and word structures. On page 33 there is a typographic error in the sentence "Are you feeling a *contaction*" (should be "contraction").

Chapter 6 deals with the admission process. Obtaining consent and demographic information is a vital part of admission, and Chapter 6 does a good job of identifying important questions to gather information and inform the patients of his or her rights.

Chapter 7 is based on a visit to a family practitioner. The dialogue on acquired immunodeficiency syndrome seemed complicated and long, but the terminology is very specific and can aid clinicians in explaining the disease process in great detail. The detailed instruction can ease the communication process between provider and patient. Some words are difficult to pronounce, even for a Spanish-speaking professional, such as "quirurgicas," which means "surgical." However, the author does a good job with pronunciation, and this helps the reader in saying the words properly.

Chapter 8 is helpful for general information-gathering with a pediatric patient. A clinician would be able to obtain a good history and physical using this outline. Common childhood illnesses are illustrated and basic care instructions for a newborn are well outlined in this chapter. On Page 100 there are 2 versions of complete blood count translation: the first ("biometria hematica") is the more complicated, whereas the other version ("quimica sanguinea completa") may be easier for the patient to understand and seems easier to speak.

In Chapter 12 there are changes in tense that do not appear to be uniform. For example, "heal" is given 2 translations: "sano," which means "healthy," and "curar," which means "to heal." The authors use "sano" with "heal" and then proceed to use "healing" with "curacion," the future tense or "curar." It would be better to use the same word used in its different tense.

Chapter 14 is a great chapter: there are many descriptive terms and the tables are especially helpful. On Page 141 there is a typographic error in Spanish. The sentence reads "Roger se levanta y va a a puerta." It should read "Roger se levanta y va a la puerta."

Chapter 15 is also good, dealing with a visit to the dentist. The topic is important and the terminology, which is not common to health care providers, appears very helpful to communicate with the dental patient.

In Chapter 18, "8 o'clock" is used in Spanish but no mention is made of whether AM or PM is meant, though in English it is specified as PM. Procedures on drawing blood and collecting urine are well translated. The chapter on pharmacy is excellent in giving instructions on how to take medications and about the pharmacy itself.

Chapter 22 is on physical examination. I particularly liked this chapter because it gives good translation on body part names and how to ask the patient to move specific joints and articulations. This information can be helpful in many clinical scenarios to many health care professionals. The chapter on greetings can benefit any hospital or office staff member. Greeting patients properly helps them to feel comfortable with the caregiver. On Page 258, "carotid" is misspelled in English. The chapters on cognates, numbers, and phrases are well-written and would be useful in communicating with Spanish-speaking patients about non-medical terms.

In Chapter 30, the color brown is distinguished between just color and skin pigmentation, which can have 2 distinct translations. Improper use of these words can be insulting to the patient and embarrassing for the caregiver. The section on pronunciation rules is well organized and easy to use as a reference for the non-Spanish-speaking health care provider. The authors cover this topic in great detail.

Unit 6 deals with grammar. The chapters in Unit 6 give very good descriptions of verb use, adjectives, and pronouns, as well as basic alphabet structure, days of the week, months of the year, and time. The chapter on numbers and counting is well organized and gives enough detail as to not confuse the reader. For example, measuring in fractions is explained well, and the use of tablespoon and teaspoon-type measurements are used as examples, which are very helpful. The cultural information section is well written and should greatly facilitate the objective of appreciating ethnicity to improve communication.

I believe, as the authors state, that it is important for a health care provider to understand Hispanic ethnicity in order to better care for Hispanic patients. Many home remedies and complementary care practices are used by Hispanics, and caregivers must relate to the patient's culture so the patient does not feel intimidated or frightened to seek medical attention. This textbook provides an excellent tool for health care professionals to communicate with and relate to their Spanish-speaking patients.

Both sentence and word indexes are arranged in alphabetical order to facilitate referencing during communication with patients. The entire book is well organized and provides useful dialogue and pronunciation to assist the reader in conversing with a Spanish-speaking patient.

My reflections are based on personal experience in translating for other health care providers and using common sense. Through my experiences in respiratory care, I can emphasize the improvement that comes with talking with patients so that the messages are clearly understood between both parties. It is very difficult for anyone to communicate with a patient in a foreign language, but the authors have done a great job of making some translations available to personnel who are interested in speaking with patients.

As a respiratory therapist, I would like to see a chapter dedicated to our profession. More and more in this country, Spanish-speaking patients are becoming evident and many have respiratory diseases. Providing respiratory care to Spanish-speaking patients and educating patients on home care instruction has become a necessity. Terminology used in daily care of respiratory patients would be helpful for therapists, nurses, and physicians.

This book is highly recommended to any health care provider interested in improving communication with and health care for their Spanish-speaking patients. I strongly recommend this book to respiratory therapists, nurses, physicians, and physician assistants.

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2001 OPEN FORUM

at the

International Respiratory Congress

The Annual Convention & Exhibition of the American Association for Respiratory Care
December 1-4, 2001 • San Antonio, Texas U.S.A

Once again respiratory care professionals have stepped forward and analyzed the things they do with critical eyes. The results of these investigations will be available during the OPEN FORUM symposia at the largest respiratory care meeting in the world, the 47th International Respiratory Congress this December in San Antonio. Abstracts and posters of their work will be presented in a format that encourages discussions and interactions among investigators and observers. It is a well accepted fact that the OPEN FORUM is the most significant and interesting portion of the Congress.

In this issue of RESPIRATORY CARE we publish all the abstracts of the papers to be presented in San Antonio (pages 1066-1147). We hope their publication raises your interest and not only encourages you to come to San Antonio, but also motivates you to look at your work environment. Hopefully, you will also be stimulated to analyze the facts through research, prepare an abstract for presentation at next year's Congress, and publish your work in a peer-review journal like RESPIRATORY CARE. We all want to do the right thing, but respiratory care medicine is a science and procedures should be supported by the proper data.

We encourage you to come to San Antonio and to participate in the exchange when the abstracts and posters are presented. The OPEN FORUM is a unique experience that will charge you up and that you will remember for the rest of your life.

See you in San Antonio!

"Findings" in Ventilators
Saturday, Dec. 1, 2001, 12:30 pm - 2:25 pm
(Room 206)

"Findings" in Artificial Airways and Their Care
Saturday, Dec. 1, 2002, 12:30 pm - 2:25 pm
(Room 207)

"Findings" in Education
Saturday, Dec. 1, 2001, 3:00 pm – 4:55 pm
(Room 206)

"Findings" in Drugs and Medications, Nebulizers, and Humidifiers
Saturday, Dec. 1, 2001, 3:00 pm – 4:55 pm
(Room 207)

"Findings" in Ventilator Techniques (Part 1)
Sunday, Dec. 2, 2001, 12:30 pm – 2:25 pm
(Room 206)

"Findings" in Home Care, Rehab, and Continuing Care
Sunday, Dec. 2, 2001, 12:30 pm – 2:25 pm
(Room 207)

"Findings" in Pulmonary Diseases and...
Sunday, Dec. 2, 2001, 3:00 pm - 4:55 pm
(Room 206)

"Findings" in Diagnostics and Monitoring
Sunday, Dec. 2, 2001, 3:00 pm – 4:55 pm
Room 207

"Findings" in Asthma and Asthma Care
Monday, Dec. 3, 2001, 9:30 am – 11:25 am
Room 206

"Findings" in Neonatal/Pediatrics Care
Monday, Dec. 3, 2001, 9:30 am – 11:25 am
Room 207

"Findings" in Ventilator Techniques (Part 2)
Monday, Dec. 3, 2001, 12:30 pm – 2:25 pm
Room 206

"Findings" in Management (Part 1)
Monday, Dec. 3, 2001, 3:00 pm – 4:55 pm
Room 206

"Findings" in Neonatal/Pediatrics Ventilator Care
Monday, Dec. 3, 2001, 3:00 pm – 4:55 pm
Room 207

"Findings" in Management (Part 2)
Tuesday, Dec. 4, 2001, 1:00 pm – 2:55 pm
Room 206

"Findings" in Ventilator Techniques (Part 3)
Tuesday, Dec. 4, 2001, 1:00 pm – 2:55 pm
Room 207

Survey of Patients Requiring Positive Pressure Ventilation
A Descriptive Study

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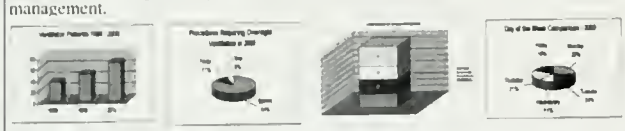
Introduction/Background: Pursuant to a significant increase of patients who required overnight post-operative mechanical ventilation a post-procedural analysis was developed to identify the type patients who required ventilatory assistance. This was performed in an attempt to discover any precipitating factors leading to the steady increases, and determine the specific patient population and/or subgroup so these patients who are at greater risk could be identified in advance. This would then assist in forecasting staffing acuity and improving patient care with proactive management.



Methods: A survey was developed to track issues thought to contribute to the need for mechanical ventilation. 65 patients were analyzed this year. Patients age, primary diagnosis, secondary diagnosis, surgical procedure, blood loss, fluid replacement, Surgeon, Anesthesiologist, date of intubation, day of week, time admitted to PICU, date extubated, time of extubation, Physician who extubated, pulmonary history, post-operative complications and reason for ventilation were all recorded. **Results:** It was discovered that the majority of patients were admitted into our PICU on Mondays. It was apparent that there was no significance between Anesthesiologists. However, in some instances overnight ventilation was required due to laryngeal swelling secondary to generous volume replacement perioperatively. Hemodynamics played an important role in 50% of the cases. Furthermore, there was no correlation between age, gender, Surgeon or Attending Physician. The biggest contributing factor was patients who had diagnoses relating to spinal deformities and henceforth received surgeries for correction. 47 of the patients had diagnosis relating the spinal deformities and 84% of the surgical procedures related to some type of spinal intervention. There are several types of procedures, which include anterior, posterior and combined spinal fusion. There was no major difference between these groups. **Conclusion:** Analysis of this prospective study reveals that the largest percentage of our patients studied who required overnight ventilation was pursuant to spinal surgery and that "generous" fluid administration further precipitated this necessity in nearly half of the cases studied. Additionally, most of our ventilator patients were received early in the week (Mondays and Tuesdays) and from this discovery a system to provide "on-call" Respiratory Care was established to "cover" the night shifts on these particular days and cases. This has resulted in a more cost-effective method of providing Respiratory Care, as well as improving the quality, safety and dimension of care and customer satisfaction. Furthermore, closer attention is being placed on pre-operative pulmonary screening and patient education as well as aggressive follow-up on these patients' pulmonary mechanics post-operatively. This has also improved patient outcomes and will hopefully shorten the length of stay.

OF-01-004

USE OF TOTAL FACE MASK (TFM) RESULTS IN INCREASED RESPONSIVENESS WHEN COMPARED WITH SIX OTHER MASKS DURING EX-VIVO NONINVASIVE VENTILATION

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Background Today's clinician has several options when choosing masks for non-invasive ventilation. It was our hypothesis that mask style would not effect patient-ventilator responsiveness.

Methods We tested seven masks used in our practice: Spectrum® Disposable facemask-small (SR), -medium (MR), -large (LR), Total Face Mask (TFM), nasal mask (N) [Respironics Inc. Pittsburg, PA]; Mirage® medium (RM) [ResMed Corp, San Diego CA]; and Nasal Pillows (P) [Mallinckrodt Inc. St. Louis, MO]. A Laerdal intubation mannequin (Laerdal Medical Corp. Wappingers Falls, NY), served as a facial-interface for the seven masks. A Respironics Vision® ventilator responded to inspiratory demands triggered by a connection of the mannequin's trachea to one side of a two-compartment mechanical test lung (Michigan Instruments, Inc.). The Vision® was set in the BiPAP S/T mode with10 cmH_20 IPAP and 5 cmH_20 EPAP. Its test-lung was linked to the opposite test lung which was driven by a Mallinckrodt Puritan Bennett 7200 ventilator in the continuous ventilation pressure control mode (CMV-PC) with f=18 breaths and PIP= 30 cmH_20. The system was characterized to simulate a high drive state (P 0.1= -8.0 cmH_2O). The mechanical characteristics of both sides of the Michigan lung were: compliance=0.075 L/cm H_20; resistance =5 cmH_2O/L/sec. Data from the mannequin's ventilation was obtained using a pneumotachometer and pressure transducer placed near the airway and connected to a system for signal amplification and data recording (Astro-Med Inc., West Warwick, RI). The inspiratory delay interval (DI) was defined as the time between the negative inspiratory pressure deflection to the point pressure reached baseline (EPAP) level. Ten measurements were made for each mask. Data were summarized as mean ± standard deviation (SD). Data were analyzed using ANOVA followed by student t-tests. Each mask's internal dead-space was also measured when applied to the mannequin's face.

Results

Mask	SR ‡	MR ‡	LR ‡	RM Ψ	TFM §	NM Ψ	P ‡
Delay interval (ms) ± SD	211 ± 10	209± 14	212± 13	192± 10	168± 13	183± 16	216± 34

§ vs. Ψ, P<0 05
Ψ vs. ‡, P<0.05

Conclusions Use of the TFM interface resulted in a shorter inspiratory delay interval when compared to the other 6 masks evaluated. This was in spite of an internal mask dead space of 1365 ml, which was greater than the other 6. We feel the improved responsiveness may be due to the mask's facial seal design

OF-01-103

VENTILATOR- AND TRACHEOSTOMY-ASSOCIATED PNEUMONIA IN LONG-TERM SUBACUTE CARE

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Purpose: Subacute level of care is now provided apart from the hospital. This study was conducted to evaluate patterns of pneumonia (nosocomial vs. community-acquired) in ventilator and non-ventilator dependent children, all of whom have tracheostomy. **Methods:** One year retrospective chart review of all cases of pneumonia in a 50-bed, freestanding, pediatric subacute facility. Nosocomial or community-acquired pneumonia were diagnosed from a predetermined list of bacteria. Without a positive culture, the diagnosis was based on clinical and radiographic findings. **Results:** 107 cases of pneumonia occurred in 42 patients. 54 (51%) of cases had multiple bacteria types. Ventilator days = 8,781. Non-ventilator days = 7,036.

	All Pneumonia	Nosocomial	Community-Acquired
Ventilator dependent	113	91	22
Per 1000 patient days	12.9	10.4	2.51
Non-Ventilator dependent	42	34	8
Per 1000 patient days	6.0	4.83	1.14

Conclusions: Patients with tracheostomy alone had half the pneumonia rate compared to invasive, ventilator-dependent patients. Ventilator dependence led to twice the pneumonia rate (per 1000 patient days) for both nosocomial and community-acquired pneumonia compared to tracheostomy dependence. Community-acquired pneumonia occurs at approximately one-fourth the rate of nosocomial pneumonia in both groups. **Clinical Implications:** Tracheostomy has its own risk of associated pneumonia. The mechanical ventilator is an added risk.

OF-01-094

IMPROVEMENT OF THE CARDIAC FUNCTION BY NASAL BILEVEL POSITIVE AIRWAY PRESSURE IN A 67-YEAR-OLD WOMAN WITH MYOTONIC DYSTROPHY.

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Introduction: In myotonic dystrophy (DM) nocturnal hypoventilation due to diaphragmatic weakness causes severe desaturation. The effect on the cardiac function of this chronic respiratory failure, however, has not received much attention, because the abnormality of the cardiac function evaluated by echocardiography is minor. Here, we report a case of DM, which showed that the nocturnal desaturation was harmful to the function of the cardiac muscle and that ventilation support overcame this problem. **Case summary**: A 67-year-old woman with DM received nasal bilevel positive airway pressure (BiPAP) during the night to treat her chronic respiratory failure. The clinical course before and after treatment is summarized below.

	Before BiPAP	0.5 Y after	1 Y after
% of nocturnal SpO2<90%	90	19	14
Diurnal PaO2 (Torr)	45.3	53.3	58.5
Diurnal PaCO2 (Torr)	64.2	59.2	57.5
Left ventricular ejection fraction	0.56	0.67	0.61
Brain natriuretic peptide (pg/ml)	172	125	51

Discussion: As the plasma brain natriuretic peptide level was raised before BiPAP, we can presume the abnormality of cardiac function. It is likely due to the respiratory failure, because BiPAP reduced it. The reason why we chose nasal BiPAP is that it is less expensive and easier to apply to such patients of DM than volume controlled noninvasive positive pressure ventilation. **Conclusion**: Cardiac dysfunction is present in DM with chronic respiratory failure even though the change of cardiac function by echocardiography is slight, and ventilation support is useful to improve this abnormality.

OF-01-124

EVALUATION OF NOISE LEVELS GENERATED BY MECHANICAL VENTILATORS ON CONVENTIONAL ADULT SETTINGS; Frank Miller, RRT, Eric Davis, RRT Respiratory Department, Mayo Clinic Hospital, Scottsdale, AZ.

Many studies have evaluated the noise generated by high frequency ventilators or environmental conditions in the ICU setting. However, little information on noise generated by ventilators on conventional adult settings is available. We questioned what the difference in noise levels generated by different ventilators on conventional adult settings was and how it differed by location to the patient. We evaluated the noise generated by eight different ventilators from each side of a patient's bed.

METHODS: The Puritan Bennett 7(0), 7(0 (with modified expiratory device), 840 and 7200, Bear 3, Siemens 900C and 300A, and Versamed I-Vent were evaluated using two Puritan Bennett 500ce heavy-duty test lungs. Each ventilator was placed on conventional adult settings (FIO_2 0.50, VT 750ml, Rate 12, Peep 5.0, Flow 60 l/m) and evaluated from equal distances of 33 inches from head center on both sides of an ICU bed. Noise levels were measured using a Simpson, model 884, sound level meter, calibrated using a Simpson B90 sound level calibrator at 114 dBA.

RESULTS: measured in dBA

Right Side	Peak Insp	Peak Exp	Mean Insp	Mean Exp	Mean Noise
PB 840	50 (±0.4)	57 (±0.4)	49 (±0.5)	53 (±0.6)	51 (±1.9)
PB 760	54 (±0.4)	71 (±0.4)	54 (±0.7)	60 (±0.6)	57 (±3.4)
PB 760 (modified)	53 (±0.4)	67 (±0.3)	53 (±0.3)	59 (±0.4)	56 (±2.9)
PB 7200	56 (±0.6)	56 (±0.2)	56 (±0.4)	56 (±0.4)	56 (±0.4)
Bear 3	58 (±0.6)	55 (±0.3)	56 (±0.5)	55 (±0.3)	56 (±0.6)
Servo 900C	59 (±0.5)	61 (±0.7)	57 (±0.6)	59 (±0.8)	58 (±1.3)
Servo 300	52 (±0.3)	61 (±0.5)	51 (±0.7)	57 (±0.5)	54 (±3.1)
Versamed I Vent	57 (±0.6)	66 (±0.4)	57 (±0.5)	62 (±0.7)	59 (±2.6)
Left Side					
PB 840	51 (±0.2)	57 (±0.2)	49 (±0.2)	53 (±0.4)	51 (±2.0)
PB 760	53 (±0.3)	64 (±0.3)	52 (±0.4)	56 (±0.3)	54 (±2.1)
PB 760 (modified)	51 (±0.2)	61 (±0.3)	51 (±0.3)	55 (±0.4)	53 (±2.1)
PB 7200	58 (±0.7)	58 (±0.3)	58 (±0.4)	58 (±0.6)	58 (±0.5)
Bear 3	57 (±0.5)	59 (±0.7)	56 (±0.4)	58 (±0.3)	57 (±1.0)
Servo 900C	56 (±0.6)	65 (±0.3)	56 (±0.4)	61 (±0.5)	57 (±0.9)
Servo 300	54 (±0.5)	61 (±0.7)	50 (±0.5)	56 (±0.4)	53 (±2.8)
Versamed I-Vent	61 (±0.6)	69 (±0.5)	59 (±0.5)	65 (±0.5)	62 (±3.0)

CONCLUSIONS: Noise levels not only vary from ventilator to ventilator, but several ventilators vary in noise based on their location to the patient, which may impact patient comfort and care. The PB 840 appears to generate the lowest noise levels of all ventilators evaluated and modifications to the PB 760 expiratory system have reduced both peak and mean noise levels. The PB 760 generates the greatest peak noise on the patient's right side, while the Versamed I-Vent generates the greatest peak noise on the patients left side. The Versamed I-Vent appears to generate the highest overall mean noise levels.

Ventilators were supplied by Mayo Clinic, Universal Hospital Inc. and MEDIQ PRN. OF-01-159

COMPARISON OF BIRD VIP GOLD VENTILATOR IN CONVENTIONAL VOLUME MODE TO DRÄGER BABYLOG 8000+ IN VOLUME GUARANTEE MODE, A BENCH STUDY

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Background: The role of "Volutrauma" in neonatal lung injury has received increased interest. Two ventilators studied offer different approaches to a volume-targeted breath. VIP Gold offers conventional volume ventilation with a decelerating flow. Babylog 8000+ offers pressure limited breaths (TCPL) (PSV) that adjust the pressure target to accomplish the selected tidal volume when "Volume Guarantee" is active. Understanding how these modes function in various clinical settings is vital to their appropriate use.

Objective: To investigate the volume delivery of two ventilators to changes in Compliance and Resistance.

Design/Methods: Using an IngMar neonatal test lung, both ventilators were set to achieve a desired expiratory tidal volume at a compliance of 1.0 ml/cm. Compliance was changed to .5, 1.5 2.0; returned to 1.0 ml/cm and the resulting tidal volume and PIP recorded for 30 breaths. The process was repeated with a 2.5mm Et tube and a 3.5mm Et tube. The Babylog was set in Assist/Control TCPL with Volume Guarantee. The VIP Gold was set in Assist/Control volume mode with decelerating flow. Both ventilators used the same standard disposable heated wire circuit (Allegiance) and Fisher/Paykel 750 heated humidifier. Target tidal volumes were 5, 10, and 15 ml.

Results: Both ventilators delivered variable expiratory tidal volumes when compliance was changed. (See figure below) The Drager Babylog 8000+ delivered large fluctuations in expiratory tidal volumes. The VIP Gold had less fluctuation in tidal volume but did not return entirely to the set tidal volume. Maximum overshoot: Drager Babylog 150%; VIP Gold 37%. Changes in resistance did not change the expiratory tidal volume significantly for either ventilator.

Conclusion: Changes in compliance resulted in significant changes to actual measured expiratory tidal volume. Such sudden compliance changes could occur in response to surfactant therapy, when an Et tube is repositioned or a pneumothorax is recognized. Volume overshoot with the Drager Babylog may be attributed to the TCPL mode. A compliance change could result in a larger volume delivery before the ventilator re-adjusts the pressure target. VIP Gold volume changes may be attributed to circuit compliance change. Both ventilators monitor delivered tidal volume at the wye. The results of the bench test warrant further study.

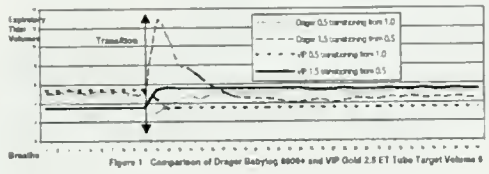


Figure 1 Comparison of Drager Babylog 8000+ and VIP Gold 2.5 ET Tube Target Volume 6

OF-01-202

AUTO-TUBE COMPENSATION (ATC) ON THE DRAGER E-2 VENTILATOR REDUCES WORK OF BREATHING (WOB) DURING CPAP

RH Kallet MS RRT, M Stobal BS RRT, RW Kraemer CRTT, J Tang MD
Respiratory Care Services, Department of Anesthesia, San Francisco General Hospital, University of California San Francisco.

Background: ATC augments ventilator inspiratory flow rate V_I to achieve the proximal airway pressure target at the distal tip of the endotracheal tube (ETT), thus counterbalancing the imposed WOB of the artificial airway. ATC can be set to compensate for a variable percentage of tube resistance. We investigated the effects of 3 levels of ATC on WOB as ETT size was varied. **Methods:** A standard WOB lung model was constructed using a Michigan Instruments TTI, set at a compliance of 27 mL/cm H_2O, powered by a Veolar ventilator set to create a V_T demand of 500 ml at a respiratory rate of 24 and a peak V_I demand of 50 L/m. The Drager E-2 treatment ventilator was set at CPAP of 5 cm H_2O and a flow trigger of 5 L/min. We measured WOB performed by the Drager E-2 ventilator (WOBv) and WOB performed by the drive ventilator to displace the "patient" compartment (WOBe). WOBe approximated the total imposed WOB (ETT + circuit). Experiments were conducted with ATC turned off and at an ATC of 100%, 75% and 50% compensation set to the corresponding ET size used in the model (8.0 and 6.0 mm ID). Measurements were made with a BICORE CP-100 monitor and 10 breaths were used for analysis. Data was analyzed using repeated-measures analysis of variance (ANOVA) and Tukey-Kramer tests. Alpha was set at 0.05. **Results:** At all levels of ATC, WOBe was significantly reduced compared to CPAP without ATC. The ability to reduce WOB diminished as the ATC level was lowered to 50%. Also, ATC 100% was not as effective in reducing WOBe as ETT size decreased (45% vs. 26% at 8.0 and 6.0 ETT size respectively). All comparisons were statistically significant.

ETT 8.0	WOBe (J/L)	WOBv (J/L)	V_I (L/m)	V_T (mL)
ATC OFF	0.69 ± .01	0.23 ± .003	68 ± 1	563 ± 5
ATC 100%	0.38 ± .02	0.99 ± .03	91 ± 2	572 ± 6
ATC 75%	0.42 ± .02	0.73 ± .01	82± 1	569 ± 3
ATC 50%	0.49± .01	0.53 ± .01	77 ± 1	575 ± 5
ETT 6.0				
ATC OFF	1.45 ±.02	0.28 ± .004	54 ± 0.7	552 ± 4
ATC 100%	1.07 ± .01	1.06 ± .01	64 ± 0.7	589 ± 3
ATC 75%	1.18 ± .02	0.83 ±.004	61 ± .07	580 ± 0
ATC 50%	1.28 ± .01	0.61 ± .005	58 ± .04	570 ± 0

Conclusion: ATC reduced total imposed WOB by increasing peak delivery above flow demand and probably should be used at 100% compensation. However, ATC's effectiveness appears to be diminished by the presence of a small ETT size.

OF-01-196

NEW METHOD OF FAST-TRACK WEANING OF POST-OPEN HEART PATIENT USING THE SEIMENS SERVO 300A IN PRVC WITH AUTOMODE. –Mark Rose, RRT, Mike Trevino, RRT, Sharon Trongaard, RRT, Gary Weinstein, MD, Presbyterian Hospital of Dallas.

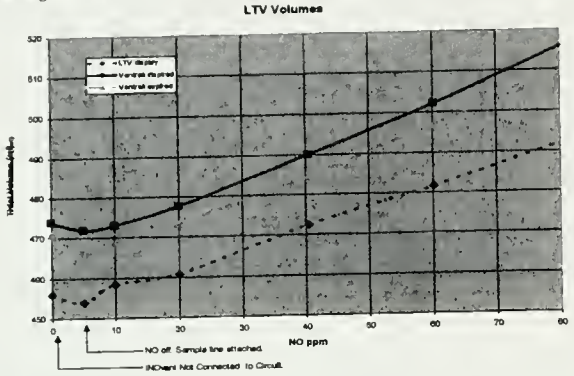
Introduction. Pressure Regulated Volume Control (PRVC) in conjunction with Automode is a ventilation application available on the Servo 300a. PRVC is a time cycled, pressure limited, control mode that will deliver a preset target volume by automatically varying the inspiratory pressure control level according to the mechanical properties of the lung/thorax. Automode is an adjunct to PRVC that allows the ventilator to switch back and forth between a machine established rate and a patient established spontaneous rate (Support). The application of this ventilator strategy may be beneficial in effectively and efficiently liberating patients from the ventilator. The following case summary highlights the benefits of this application in a postoperative cardiac surgery patient. Case Summary. After having a Ross procedure in the usual fashion under standard general anesthesia, a 55-year-old male with a history of aortic insufficiency and stenosis was placed on the Servo 300a in the PRVC mode with the Automode on. Ventilator settings were as follows; f:10, Vt:900cc, FiO2:.70, PEEP:5cwp. Our extubation criteria were; spontaneous RR < 25bpm, spontaneous Vt >300cc, FiO2 <.50, PEEP <6cwp, Pressure Support <13cwp, and ETCO2 within 15 mm Hg of baseline. An initial ABG was drawn after 20 minutes and correlated with the ETCO2 and SaO2 monitors. Appropriate changes were made at this time, adjusting rate and FiO2 to achieve normal blood gas parameters. After spontaneous respirations were noted, the Automode/Support adjunct was utilized. The patient's lung mechanics were evaluated and hemodynamic stability was verified with the RN. The FVC was > 10ml/kg of IBW and MIP was > -20cwp. The set Vt was reset to 300cc. After 30 minutes, an ABG was drawn and found to be acceptable. The patient was then extubated without difficulty. Results. A November 1998 publication from the Cardiology Roundtable presented a FACT BRIEF titled "National Benchmark Information Regarding Post-Open Heart Ventilation Weaning". The identified benchmark was 6-8 hours with outliers defined as ventilator time greater than 12 hours for comparable hospitals to our own. Our facility benchmark, based on 587 cases in fiscal year 2000, reflected a mean of 8.4, a median of 7, and a mode of 5 hours respectively. As the table below reflects, this patient was well below both benchmark targets.

Total time on pump in the OR	Total time on ventilator	Average Weaning Time
181 minutes	3 hours	45 minutes

In conclusion, and for this patient, PRVC in conjunction with Automode was an effective tool, capable of utilizing less therapist time while still effectively and quickly liberating patients from the ventilator. Further, more controlled studies are warranted to evaluate the long-term effectiveness of this promising approach to weaning ventilated post-operative open-heart patients.

OF-01-213

Lab Evaluation Of Pulmonetic Systems LTV Ventilator With The Datex-Ohmeda iNOvent. John Newhart RCP, Craig Pedersen RCPT, Timothy Morris MD. UCSD Medical Center, San Diego CA. **Background:** At our institution we use inhaled nitric oxide (INO) to treat hypoxia and pulmonary hypertension. Most of these paticots are on mechanical ventilatioo. When a mechanically ventilated patient requires transportation within the medical center they are frequently placed on the LTV (Pulmonetic Systems, Colton CA) portable ventilator. The purpose of this study is to determine the effects of using the INOvent (Datex-Ohmeda Madison WI) in conjunction with the LTV. We tested for differences in set vs. indicated volumes, and effects on trigger sensitivity. **Methods:** Tidal volume accuracy was investigated by placing a pneumotach (Novametrics VenTrack) between the patient "Y" and a 2 chamber TTL (Michigan Instrumeots). Inspired and expired volumes were recorded from the VenTrack as well as displayed exp. volumes from the LTV. Volumes from both sources were plotted out oo a graph for comparison. Triggering was assessed by attaching the LTV to one side of a double chamber lung with a Puritan Bennett 840 driving the other chamber. Patient effort was simulated by a lift bar on the drive chamber lifting the driven side. Sensitivity levels of 2,4 and 6lpm, at doses of 0,5,15,20,40,60 and 80ppm NO and without the INOvent attached were tested. The flow was measured by placing the VenTrack flow sensor in the expiratory limb of the circuit and identified as the maximum negative deflection immediately before the start of inspiratioo. **Results:** Measured volumes on the VenTrack and LTV correlated well throughout the range of NO doses tested. Volumes increased proportionate to the NO dose. Measured triggering was up to 2 lpm above the set point throughout the range of variables tested. This was easily compensated for by adjustment of the flow trigger.



Conclusions: Our preliminary testing found the LTV ventilator to be compatible with the INOvent.

OF-01-218

AN INVESTIGATION TO DETERMINE THE COMPATIBILITY OF THE HAMILTON GALILEO VENTILATOR AND THE JET BUNNELL IN A NEONATAL LUNG MODEL.

Jim Keenan BS RRT, Troy Lynch RRT Respiratory Care Service, Primary Children's Medical Center, Salt Lake City, Utah.

Introduction Our facility is in the process of reevaluating the standard of care ventilator for our level III NICU. The Bunoell Jet ventilator is often used in tandem with our curreot standard ventilator for patients meeting jet ventilation criteria. The reevaluatioo process must insure that whatever ventilator staodard is chosen, that it is compatible with the Jet Bunoell. Hamilton Medical Inc. has recently come out with neonatal software upgrades for their Galileo veotilator. The package includes time-cycled pressure-limited modes with a aeonatal flow sensor. Since this ventilator is one of many that is being considered we decided to do a bench test to determine its compatibility with the Jet Bunoell since it had not been previously reported in the literature. **Methods:** Testing coosisted of ventilatiog an IngMar Medical Neonatal test lung using the Galileo and the Jet in tandem uoder two test conditions. Each test condition was performed using a triple lumeo 3.0 and 4.0 ETT. In test condition one, PIP was varied on the Galileo from 5 to 35 cmH20 in 5 cmH2O incremeots. The jet PIP was operated at 5 coiH2O higher than the Galileo and also increased in 5 cmH2O increments, aloog with the Galileo, to 40 cmH2O All other ventilator settings remained the same. These setting were: Galileo: time cycled - pressure limited SIMV, rate: 5, Peep; 5, inspiratory time: 0.4 sec., flow: 6 Lpm, trigger 1.5 Lpm. Jet: rate 420 with an on-time of 0.02 sec. In test condition two the Jet rate was varied at rates of 300, 420, and 500. All other veotilator settings remained the same. These setting were: Galileo: time cycled - pressure limited SIMV, PIP: 20 cmH2O, rate: 5, Peep; 5, inspiratory time: 0.4 sec., flow: 6 Lpm, trigger 1.5 Lpm. Jet: PIP: 25 cm H2O with an on-time of 0.02 sec. Data was gathered for approximately 5 mio. for each variable test coodition. All measured and monitored Galileo data was captured using the Galileo Data Logger software package. **Results:** Both veotilators operated efficiently uoder these test conditions. All measured and monitored data from the Galileo were consistent, reproducible, and withio acceptable limits. Upon initial investigation under test condition one, it was discovered that the PIP of the Galileo must always be at least one cmH2O below the PIP of the Jet. If oot, the Galileo would report a seosor malfuoctioo. During the alarm coodition the Galileo contioued to fuoctioo appropriately. This may be of concern, as some clinicians prefer to ventilate with cooventional PIP's the same or higher than the jet. **Discussioo:** Wheo new neonatal ventilator technology becomes available it is important to consider all aspects of its operation. Those facilities that promote the use of Buooell Jet veotilatioo must consider if the two devices are compatible. Io addition, many NICU's are recogniziog the benefit of flow seosor mooitoring technology. The sensor and ofteo its location create more difficulties when the jet us used. **Conclusioo:** We feel that it is safe to use the Hamilton Galileo in tandem with the Bunnell jet as long as it is clinically acceptable to use jet PIP's greater than the Galileo.

OF-01-231

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THE PULMONETICS LTV 800 VENTILATOR SUPPORTS AN OPEN BREATHING CIRCUIT FOR PORTABLE MOUTHPIECE VENTILATION IN NEUROMUSCULAR PATIENTS

Louie Boitano MS, RRT, Yoshihiro Otaki MD, Joshua Beoditt MD, Departments of Respiratory Care, and Pulmonary and Critical Care Medicioe, Uoiversity of Washington Medical Center, Seattle, WA.

Volume driven mouthpiece ventilation has been shown to provide both adequate ventilatory support aod an improved quality of life when compared to ventilation by tracheostomy in neuromuscular patients with chronic respiratory failure. To date, mouthpiece ventilation has been supported by pistoo actuated volume ventilator systems. These ventilators are heavy and require significant space, makiog their instillation on power wheelchairs for portable ventilatory support both costly aod time consuming. Patients using these systems are often limited in their ability to move within their home eoviroment because of the increased length of the wheelchair ventilator system. We tested a new model 800 of the LTV series ventilators by Pulmonetics Inc., Colton, CA. The compact, portable LTV 800 ventilator was re-engioeered to support assist breath triggeriog in the assist/control mode by negative pressure whereas the previous models have been flow triggered The LTV 800 was tested using an open breathing circuit systeo consisting of an Airlife volume ventilator circuit, (Allegaoce Healthcare Corp.), combioed with a 15mm angled mouthpiece, (Respironics Inc.). The ventilator was tested in the assist/cootrol mode at variable tidal volumes, breath rates and inspiratory flow rates. The low pressure alarm was set at 0 centimeters of water pressure. The ventilator produced accurate breath volumes on a test lung from 500 to 1500 cc's. Low inspiratory flow rates did not trigger the low pressure alarm and the control breath rate could be set as low as one breath per minute without ventilator alarming by adjusting the apnea duration to 60 seconds. Negative pressure triggering was set as low as −1 centimeter of water pressure without causing autocycling machine breaths. The LTV 800 model ventilator supported an open breathing circuit for mouthpiece ventilation uoder a variable range of breath volumes and inspiratory flow rates without low pressure alarming. The LTV 800 ventilator can provide a significaot gain in the support of portable open circuit mouthpiece ventilation for oeuromuscular patients with respiratory failure. The LTV 800 ventilator is significantly more compact and lighter weight than currently used portable volume ventilators. It may provide a lower cost aod faster instillation for power wheelchairs as well as the potential for significantly greater chair maneuverability with a more compact wheelchair ventilator system.

OF-01-265

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UNFORESEEN COMPLICATION OF NASOTRACHEAL SUCTIONING, A CASE STUDY

Christopher M. Cella, RRT, Adult Clinical Specialist, Joshua O. Benditt, MD, University of Washington Medical Center, Seattle, Washington

Case Summary: A 79 year old male, five days status post coronary artery bypass grafts times 4 was an inpatient in our adult intensive care unit. The patient was receiving .50 oxygen via cool aerosol facemask, postural drainage and percussion every 4 hours, and nasotracheal suctioning every 4 hours and PRN as necessary. The patient had an ineffective spontaneous cough, and was unable to clear or expectorate secretions on his own. Chest x-ray revealed diffuse bilateral infiltrates.

Because the patient required suctioning on a regular basis, a #8 Roush nasal airway was maintained to help prevent nasal irritation and bleeding. Following a treatment of postural drainage and percussion, on auscultation the patient had coarse bilateral ronchi throughout his chest, he had a weak loose nonproductive spontaneous cough. It was deemed necessary to suction the patient. With the assistance of his RN, the patient was preoxygenated with 1.0 oxygen prior to the procedure. Using sterile technique, a 14 french Allegiance suction catheter was lubricated with KY jelly, prior to insertion into the nasal airway. The catheter was advanced into his oropharynx, and vacuum applied. Approximately 15 ml. of tenacious beige secretions were aspirated. After 30 seconds, the catheter was advanced during inspiration in attempts to remove secretions from his trachea. Vacuum was applied, but no secretions were aspirated. The catheter was advanced and retracted several times in effort to enter the trachea. Vacuum was applied and again no secretions were aspirated. At this time catheter was withdrawn from the airway. As it was retracted, the nasal airway became dislodged and was removed from his nare simultaneously. Much to our surprise, the end of the catheter had been tied into a knot! We suspect that the patient used his tongue to twist the catheter into this configuration.

Discussion: Hazards and complications of NT suctioning from the AARC Clinical Practice guidelines include laceration of nasal turbinates, perforation of the pharynx, nasal irritation/bleeding, tracheitis, and mucosal hemorrhage. In this unusual case it was most likely beneficial that the nasal airway was in place, as it cleared the way as the knotted end of the catheter was removed from his airway. Clinicians need to be aware of this potential complication when performing this procedure.

OF-01-002

COMPARISON OF CLOSED-SYSTEM ENDOTRACHEAL TUBE SUCTION TECHNIQUE TO OPEN SUCTIONING IN SURFACTANT DEFICIENT NEWBORN PIGLETS.

Pat Meyers RRT, C Worwa RCP, M Mammel MD. Infant Pulmonary Research Center, Children's Hospital, St. Paul,MN

Introduction: We compared hemodymanics, arterial blood gases and change in FRC (Respitrace™, Ardsley, NY) while using a closed-system suction adaptor (Neo-Link™, Corpak Medsystems, Wheeling,Il) to open endotracheal tube suctioning in 12 Newborn piglets with saline lavage induced lung injury. We hypothesized that open suctioning (OS) would produce greater hemodynamic and blood gas change than closed suctioning (CS). **Methods:** A crossover design was used; 6 animals received OS then CS, 6 CS then OS. With each treatment, suction catheters were inserted to 5 mm beyond the tip of the endotracheal tube, and suction pressure (-100 mm Hg) was applied for 10 seconds. Data were collected before and at 1, 5, 10, 15 minutes following the procedure. Arterial blood gases were continuously monitored (Paratrend 7, Diametrics Medical, St. Paul, MN). Data were analyzed using ANOVA and techniques for crossover design.

Results:

Time	BP		pH		PCO2		PO2		a/A		OI		△FRC ml/kg	
	OS	CS	OS	CS	OS	CS	OS	CS	OS	CS	OS	CS	OS	CS
Before	47	48	7.29	7.30	44	43	49	53	.075	.081	27	24		
1 min	46	47	7.26*	7.31	48*	42	35*	55	.055*	.085	26*	24	-4.3*	-0.89
5 min	46	47	7.29	7.31	43	42	53	55	.081	.083	25	23		
10 min	47	48	7.29	7.31	43	43	54	56	.083	.086	24	23		
15 min	49	48	7.28	7.31	45	42	50	58	.077	.090	26	23		

*p<0.01 OS vs CS at 1 minute

Conclusions: We saw no hemodynamic differences of the means between OS and CS techniques. However, percent change from absolute value at 1 minute was significant for HR and BP, p<0.01, OS vs CS. At 1 minute after OS, pH was significantly lower with higher pCO2, while pO2 and a/A were lower and OI was higher than corresponding values obtained during CS. Change in lung volume was significant OS vs CS. These data suggest CS techniques may provide better physiologic stability during and after endotracheal suctioning. Neo-Link™ and partial funding provided by Corpak Medsystems.

OF-01-009

EFFECT OF EXTENDING CLOSED SYSTEM SUCTION CATHETER INTERVAL ON VENTILATOR ASSOCIATED PNEUMONIA RATES

Virginia DeFilippo, MS, RRT, Jeffrey Topal, MD, Lynn Tanoue, MD, Patricia Reagan-Cirincione, Ph.D., Yale-New Haven Hospital, New Haven, Connecticut

BACKGROUND: Closed system suction catheters (CSSC) are changed at 24 hour intervals by manufacturer recommendation. Several studies have examined extending CSSC changes from 24 hours to 7 days using Ventilator Associated Pneumonia Rate (VAPR) as an outcome measure for practice change, with no statistically significant change in VAPR noted. We evaluated the effect on VAPR of changing CSSC from every 24 hours to 7-day intervals with the ventilator circuit change at our institution. Additionally, we evaluated the number of CSSC failures during the first 2 months of the study. **METHOD:** The study was conducted in the Medical Intensive Care Unit (MICU). Respiratory Care and MICU staff were informed of the study. For a six-month period, mechanically ventilated patients had CSSCs changed on a 7-day interval when the ventilator circuit was changed rather than a daily change. VAPR was used as an outcome measure. Historical data on VAPR from the 6 months prior to the practice change were used as a comparative baseline. A CSSC could be changed at less than 7 days depending on the integrity of the unit as assessed by the respiratory care practitioner. All CSSCs requiring change-out before 7 days due to integrity or other issues were tracked. Respiratory Care staff were instructed to record any CSSC failures during the first 2 months of the study. Staff recorded the reason for the failure and the number of days the CSSC was used. A CSSC failure was defined as any situation in which the respiratory therapist deemed the integrity of the CSSC to be unsatisfactory. During the study, there were 169 ventilated patients with 1,342 ventilator days and 25,745 ventilator hours. Average ventilator length of stay was 6.35 days. Epidemiology and Infection Control staff monitored VAPRs. VAPR data was collected in compliance with National Nosocomial Infection Surveillance (NNIS) criteria. One way Analysis of Variance (ANOVA) was performed for statistical analysis.

RESULTS: Daily vs. 7 Day CCCS Changes:

	Daily	7-Day	
Mean Ventilator Days	253.3	223.7	p = .33
Mean VAPR	13.7	3.6	p = .04

CSSC Failure Data:

Ventilator Days	407
Ventilated Patients	69
Catheters Used	113
Catheter Failures	8
Avg # of days use before catheter failure	4.5
% Catheter failures to catheters used	7.07%

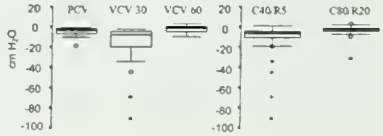
CONCLUSION: There was a significant reduction in VAPR with CSSC changes every seven days versus daily changes. The seven-day catheter failure rate was 7.07%. Since the sample size was small a further confirmation of these findings is recommended

OF-01-140

A BENCH EVALUATION OF ALVEOLAR PRESSURE CHANGES DURING ENDOTRACHEAL SUCTION.

Steve Y. Wong, MD, Guilherme Schettino, MD, Robert Kacmarek PhD RRT FAARC, Dean Hess PhD RRT FAARC. Massachusetts General Hospital and Harvard Medical School, Boston MA.

Closed suction may avoid alveolar derecruitment (Intensive Care Med 2001; 27:648). However, one study reported negative airway pressures using this procedure (Acta Anaesthesiol Scand 2001;45:167), which we reasoned may result from inadequate ventilator flow to replenish that withdrawn by the suction catheter. We studied the relationship between alveolar pressure and ventilator modes during open and closed suctioning. **Method:** A Michigan Instruments TTL simulated a resistance of 5 cm H_2O/L/s and compliance of 40 mL/cm H_2O (C40/R5), or a resistance of 20 cm H_2O/L/s and compliance of 80 mL/cm H_2O (C80/R20). An 8 mm endotracheal tube size was used. A Puritan-Bennett 7200 ventilator was used with volume control at a flow of 30 L/min (VCV 30), volume control at 60 L/min (VCV 60), or pressure control (PCV). A V_T of 500 mL and rate of 15/min were used (I:E ratio 1:3 for PCV). Trigger sensitivity was –1 cm H_2O or flow trigger of 3 L/min (base flow 10 L/min or 20 L/min). PEEP of 5 and 10 cm H_2O were used. Experiments were performed with a 14 French catheter (Ballard Trach Care), which was advanced to the distal end of the endotracheal tube. Suction pressure of 120 mm Hg or 180 mm Hg was applied for 10 s. Pressure was recorded from the entrance to the bellows (Ventrak). The experiment was also performed with the ventilator Y-piece disconnected from the inline suction catheter to simulate open suctioning. Pressure drop below PEEP was measured post-hoc from the pressure waveform. **Results:** During closed suction, the pressure drop below the set PEEP in the bellows was not affected significantly by PEEP level (P=0.32), trigger method (P=0.51), or suction pressure (P=0.31). Pressure drop was significantly affected by resistance/compliance setting (P<0.001) and flow setting (P<0.001) as shown in the figure below. With open suction, the pressure drop was –8 cm H_2O. **Conclusions:** When flow from the ventilator was adequate (PCV or VCV 60), alveolar pressure drop below PEEP was small. When PEEP is used, this should rarely result in sub-atmospheric pressure in the lung. When open suction is used, which results in no PEEP, the alveolar pressure drop is always sub-ambient. These data suggest that closed suction may useful as a technique to avoid alveolar derecruitment during the suction procedure.



OF-01-141

Use of Closed vs Open Tracheal Suction Catheters: Survey of User Practice

Mark Siobal BS RRT, Respiratory Care Services,
San Francisco General Hospital, UCSF Dept. of Anesthesia

Background: Utilization of closed tracheal suction catheters (CTSC) is currently common practice. Evidence of physiologic benefit, reduced risk of infection, ease of use, and reduced personnel time support this trend. Higher costs and user perception of ineffective secretion removal present barriers to the acceptance of CTSC as a standard of care. Continued use of open suction catheters promotes the practice of ventilator circuit manipulation and increases infection risk. To estimate the extent of use and prevalence of practices that may counter benefits of CTSC, a user survey was conducted.

Methods: A survey was distributed via email to respiratory care departments in 101 university affiliated and 61 community hospitals in North America. A total of 38 responses were received.

Results: Use of CTSC is the standard of practice in 68% of the responding facilities. The majority of sites (59%) change catheters at ≤ 48 hour intervals. The impact on ventilator associated pneumonia was reported to be reduced or unchanged in 54% of the responding sites. User perception of effectiveness was favorable in 84% of the respondents. User practice of hyperinflation by disconnection from the ventilator, saline lavage to mobilize secretions, and reverting to open suction, was prominent (57%, 100%, and 68% of respondents respectively).

Freq. of CTSC use	All Patients 26	Selected Patients 11	Not Used 1	
Freq. of catheter change	Q 24 hrs 16	Q 48 hrs 6	≥ Q 7 days 9	PRN 6
Impact on Ventilator Associated Pneumonia	Reduced 8	Unchanged 12	Increased 0	Undetermined 17
Perception of effectiveness	Always Effective 14	Often Effective 17	Sometimes Effective 4	Never Effective 2
Hyperinflation with CTSC	Always 4	Often 5	PRN 25	Never 3
Hyperinflation method	Mech. Vent. 12	Manual Vent. 5	Both 16	
Saline lavage during suction	Always 7	Often 8	PRN 22	Never 0
Use of open suction	Often 4	PRN 21	Never/Rarely 12	

Conclusion: The results indicate that despite a high perception of effectiveness in removal of airway secretions, practices that result in ventilator circuit manipulation and potential infection risks are common. Modifications in catheter design and user technique are areas of refinement that may reduce these practices. Further evaluation of the impact of the humidification method, hyperinflation technique, use of saline lavage, and catheter maintenance practices may also be helpful in optimizing use of the device.

OF-01-183

INADVERTENT EXTUBATION RATES IN A TERTIARY CARE MEDICAL CENTER, **Michael H. Terry RCP RRT, Thomas P. Malinowski RCP RRT, Loma Linda University Medical Center and Children's Hospital, Loma Linda, California, 92354**

Purpose: Inadvertent airway extubation (IE) is a hazard for intubated patients requiring mechanical ventilation, and has the potential for increased morbidity or mortality. We sought to better understand our incidence of IE, compare our rates to the rate of accidental extubation with previously published studies, and understand the consequence of IE in multiple ICU populations.

Design: Prospective recording by bedside RCP's of IE in seven intensive care units for six (6) years (1994 – 2000). The intensive care units are identified as: Neonatal Intensive Care (NICU), Pediatric Intensive Care (PICU), Coronary Care (CCU), Adult Cardiothoracic Care (CTICU), Surgical Intensive Care (SICU), Medical Intensive Care (MICU), and a Community Hospital Intensive Care (CMCICU). The primary outcome measures included the occurrence of IE (10/94 – 12/2000), cause of IE (7/96 – 1/2000), and outcome of IE (2/97 – 1/2000).

Results: IE's are indexed to 100 ventilator days:

Intensive Care Unit	**Total number of IEs**	**Number of Ventilator Days**	**Avg. IE rate per 100 vent. Days (SD)**	**Reintubation within 24 hours (%) 2/1997- 1/2000**
NICU	211	30,760	0.69 (0.38)	31/56 (55%)
PICU	126	19,329	0.65 (0.46)	10/40 (25%)
CCU	13	3,140	0.41 (0.39)	1/3 (33%)
CTICU	50	4,147	1.21 (1.9)	5/8 (63%)
SICU	91	13,226	0.69 (0.48)	7/22 (32%)
MICU	68	14,072	0.48 (0.42)	10/25 (40%)
CMCICU	22	3,432	0.64 (0.57)	2/2 (100%)

Sedation related and procedure related IE's were most common in the NICU and PICU. Motion or restraint related IE's were observed in all ICU's.

Discussion: IE is an event that occurs in all intensive care units. Our data does not demonstrate a higher preponderance of IE in the infant and child population, contrary to previously published reports. The overall incidence is comparable to previously published data. We are now focusing our interest on unit specific causal and outcome trends.

OF-01-236

THE ASSOCIATION BETWEEN NASOPHARYNGEAL SUCTION AND OXYGEN REQUIREMENT IN BRONCHIOLITIS PATIENTS. Tami Zemlicka-Dunn RRT, BS, Julie Ballard, RRT, BS, Quality Care Assessment Team (QCAT) members; John Salyer, RRT, MBA, FAARC. Respiratory Care Service, Primary Children's Medical Center, School of Medicine, University of Utah

Introduction: We have long believed that nasopharyngeal (NP) suctioning of the hypopharynx with a catheter is an important part of the care of pediatric bronchiolitis patients. Indeed this has been our standard of care since 1997. However, many others use bulb suction or similar non-invasive techniques. We sought to determine if we could quantify the effect of NP suctioning on the ability to wean these patients. Our QCAT members regularly assess patients with bronchiolitis. Our standard of care during assessments includes initially weaning oxygen of patients if possible based on pulse oximetry. Patients are then suctioned if necessary and weaned if possible. **Methods:** Data were gathered using retrospective chart review for the period from Oct 2000 to Apr 2001. Inclusion criteria were 1) diagnosis of bronchiolitis, 2) ≤ 24 months of age, 3) non-ICU admission, 4) documentation of floor suctioning while receiving oxygen. Data included whether suctioning episodes were the 1st, 2nd or 3rd since being admitted to the floor for each patient, and whether or not suctioning resulted in weaning of the oxygen. Our standard of care is to wean patients at pulse oximetry levels ≥ 88%. **Results:** 421 patients met the inclusion criteria, of which there were a total of 1,141 1st, 2nd or 3rd suctioning interventions. During the study period we had no formal or informal reports of suctioning related morbidities. **Discussion:** It is clear that even after traditional weaning by pulse oximeter, that NP suctioning in about 1/4 of these patients results in further weaning, even during subsequent suctioning events. NP suctioning clearly has a positive effect on the need for oxygen. Some consider NP suctioning controversial in this population. We have been told it is "too traumatic", and "not effective". Our findings suggest that it is effective, and our experience indicates that it is safe. We recommend the use of NP suctioning in the care of bronchiolitis patients.

Suctioning episodes resulting in O_2 weaning

suction order	# of suction episodes	# and (%) of episodes resulting in weaning
1st suction	421	129(31)
2nd suction	388	92 (24)
3rd suction	332	81 (24)

OF-01-233

THE EFFECT OF NP SUCTIONING ON SYMPTOM SCORES IN BRONCHIOLITIS PATIENTS Glenna McKinley RRT, BS, Julie Ballard RRT, BS, John Salyer RRT, MBA, FAARC. Quality Care Assessment Team. Primary Children's Medical Center. Salt Lake City, Utah. **Introduction:** We believe nasopharyngeal suctioning (NP) with a catheter down to the hypopharynx plays an important role in the care of pediatric pts with bronchiolitis. We use a previously described symptom score (range 0-9) we call the bronchiolitis score (BS) which improves in most of these pts after suctioning, reducing the need for bronchodilators[1]. This study was designed to describe the effect of NP on BS in these pts. **Methods**: Data were collected from the medical record from November 2000 - April 2001. Inclusion criteria were all pts with a diagnosis of bronchiolitis, age ≤ 24 months, and non-ICU. We included pts who had documentation of the BS before and after at least one NP intervention within the first 24 hrs of admission. Data were compiled and standard descriptive statistics computed. Pts and NP interventions were sorted according to whether there was improvement, worsening, or no change in the BS after NP. A decrease in the BS ≥ 1 was an improvement, while an increase ≥ 1 was a worsening. **Results**: We identified 581 pts who met the diagnostic and age criteria, of whom 474 had adequate documentation. There were 1789 NP interventions in these pts.

Description of bronchiolitis score:

	RR	Wheezing	Retractions
0	≤ 30	No wheezing, good air exchange	None
1	31-45	Late expiratory with stethoscope only	Mild (1 place)*
2	46-60	Entire expiratory or inspiratory phase with stethoscope only	Moderate (2 places)
3	>60	Loud wheezes without stethoscope or no wheezing in the presence of severely diminished exchange	Severe (3 or more places)

* indicates the number of sites of retractions

Results of suctioning data in tables are numbers (%)

	Suctioning Interventions	Patients
Improvement	1080 (60)	385 (81)
No Change	664 (37)	85 (18)
Worsened	45 (3)	4 (1)
Total	1789 (100)	474 (100)

Results among pts who showed improvement only

Magnitude of Improvement	Suctioning Interventions
By 4-7 points	29 (3)
By 2-3 points	315 (29)
By 1 point	736 (68)
Total	1080 (100)

Discussion: 81% of patients had at least one episode of NP suctioning resulting in an improvement in symptoms, and of these about 1/3 were large improvements. We have received no formal or informal reports of adverse events associated with NP in any of these pts. Our experience is that properly trained staff can safely perform NP. We suggest that NP is an important part of the care of bronchiolitis pts. We speculate that improvements in NP are associated with improved oral feeding, and thus reduced need for IV fluids, and reduced need for supplemental oxygen. We plan to study this further.

1. Respir Care (abstract). 2000;45:1009

OF-01-241

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THE INTERACTION OF NASOPHARYNGEAL(NP) SUCTION AND ALBUTEROL IN THE TREATMENT OF BRONCHIOLITIS: A TWO YEAR COMPARISON

Kim Bennion BS RRT, Julie Ballard BS RRT, QCAT Team Members and John Salyer MBA RRT, Respiratory Care Services, Primary Children's Medical Center, School of Medicine, University of Utah. **Introduction:** Our hospital has a multi-disciplinary assessment team that specializes in the care of the bronchiolitis. The team is called the Quality Care Assessment Team (QCAT) and has 7 specially trained RCP's. They daily assess all bronchiolitics who are ordered on respiratory interventions. The team employs a standardized protocol for aerosolized albuterol, NP suctioning with a catheter and a symptom based respiratory scoring system. The protocol includes an albuterol trial that can be defined as: baseline score, NP suction, repeat score 10-15 minutes post suctioning, an albuterol treatment (tx) if deemed necessary and a repeat score 10-15 minutes post treatment completion. The score is based on respiratory rate, breath sounds, and retractions with each of these being scored on 4 levels (0-3). Scores are classified as 0-1 normal, 2-3 mild distress, 4-6 moderate distress, and 7-9 severe distress. We sought to determine if intervention with NP suctioning reduced the need for further intervention with albuterol in a repeat of a study we conducted last year (Respir Care 2000;45:1009). **Methods:** Data on interventions and scores were extracted from our data systems. Inclusion criteria were: (1) diagnoses of brocnhiolitis and ≤24 months of age (2) an ordered trial of aerosolized albuterol and (3) a complete set of scores defined as scores as baseline, post suctioning and post tx. An improvement was defined as a decrease in the respiratory score ≥1 from baseline to post intervention (suctioning or aerosol tx.). Patients were classified according to whether or not their respiratory scores improved, remained unchanged or worsened after each intervention. **Results:** There were 166 patients in the 99-00 season and 167 in the 00-01 season who met the criteria. Proportions were tested for statistical significance using Chi Square analyses with significance established as $P \leq 0.006$.

	Improved Post Tx		No Change Post Tx		Worse Post Tx	
	99-00 Season	00-01 Season	99-00 Season	00-01 Season	99-00 Season	00-01 Season
Improved Post Sx	9 (5)	10 (6)	70 (42)	58 (35)	9 (5)	18 (11)
No Change Post Sx	13 (8)	20 (12)	54 (32)	43 (26)	5 (3)	7 (4)
Worse Post Sx	4 (2)	6 (3)	2 (1)	4 (2)	0 (0)	1 (1)

Data are reported in numbers and (%) of patients.

Discussion: The debate continues regarding the efficacy of respiratory interventions in bronchiolitis care. With the use of the scoring system, we try to objectively determine which if any intervention(s) result in pt improvement. Data from both seasons appear to support suctioning the nares using a catheter obviates the need for further tx with albuterol. We feel that the reproducibility of our results gives our finding considerable validity.

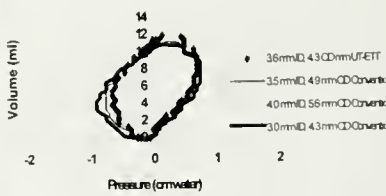
OF-01-243

RESISTANCE CHARACTERISTICS OF ULTRATHIN-WALLED AND CONVENTIONAL ENDOTRACHEAL TUBES FOR NEONATES

Paul N. Austin, CRNA, PhD (LtCol USAF NC)[1]; Scott Moschel, RN, BSN[2]; Christopher Ehrler, RN, BSN[2]; Robert S. Campbell, RRT, FAARC[2]; Richard D. Branson, RRT, FAARC[2]; [1]Uniformed Services University of the Health Sciences, [2]University of Cincinnati

Background: Kolobow introduced the concept of an ultrathin-walled endotracheal tube (UT-ETT) in 1994. (Biomed Instrument Technol 1994;28:123). Commercially available UT-ETT have recently become available (T-Wall, Vital Signs, Totowa, NJ). We evaluated the resistance characteristics of conventional ETT and new UT-ETT in the laboratory.

Methods: The resistance of three samples of each ETT (conventional ETTs: 3 mm ID, 4.3 mm OD; 3.5 mm ID, 4.9 mm OD; and 4 mm ID, 5.6 mm OD and UT-ETT 3.6 mm ID, 4.3 mm OD) were measured using a RT-200 analyzer (Allied Products, St Louis, MO). The ETTs were cut to the same length 13 cm that included the connector. Each ETT was position in the same curvature using a clay template. Inspiratory resistance was measured at flow rates of 3, 3.25, 3.5, 3.75, 4, 5, 6, 7, 8, 9, 10, and 20 L/min. In the second part of the evaluation the ETTs were attached to a test lung (Michigan Instruments, Grand Rapids, MI) with C 0.01 L/cm H_2O, R 50 H_2O /L/s. Spontaneous breathing was simulated with a tidal volume of 12 ml and peak inspiratory flow of 2 L/min. Flow, volume, and pressure was measured at a point between the ETT and the test lung using a *CO2SMO Plus* respiratory monitor (Novametrix Medical Systems, Wallingford, CT) at a rate of 100x/s. Data was saved to the hard drive of a personal computer then exported to an Excel (Microsoft, Redmond, WA) spreadsheet for further analysis. Pressure volume curves were constructed allowing for qualitative evaluation of imposed inspiratory work



Results: For the same OD, the UT-ETT results in lower resistance and lower work of breathing. Compared to the 3.0 ID ETT the UT-ETT produced 54-56% less resistance at flows of 1-10 L/min. Conclusions: The new UT-ETT provides lower resistance and reduced work of breathing at the same OD (same risk of tracheal damage). Future clinical trials should evaluate any impact.

OF-01-257

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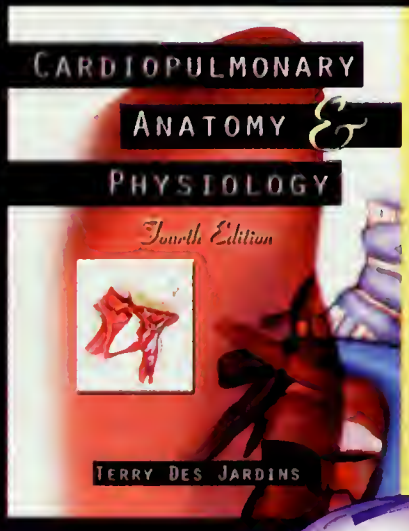

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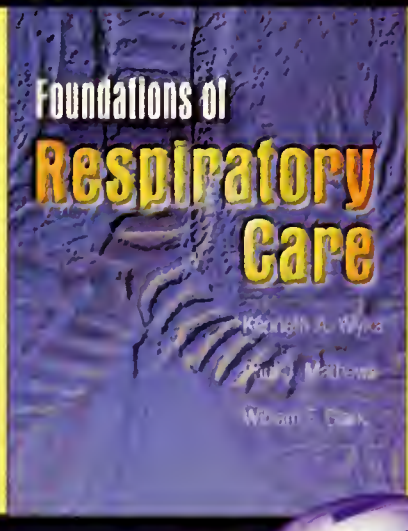

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CORRELATIONAL STUDY OF PREDICTOR VARIABLES FOR PROGRAM COMPLETION IN THE RESPIRATORY CARE PROGRAM AT LABETTE COMMUNITY COLLEGE

Douglas S. Gardenhire, M.S., R.R.T., Labette Community College, Parsons, Kansas

Background: The purpose of this study was to explore whether correlations exist between multiple variables and student scores on the Health Occupations Basic Entrance Test (HOBET) in the Respiratory Care Program. **Methods:** The study performed is an ex post facto study using existing data from student files of the Respiratory Care Program at Labette Community College. Data was collected from 42 students that were accepted into the Respiratory Care Program at Labette Community College between the years of 1994 and 1996. The criteria for individuals to be included were that they were a high school graduates, they had taken the HOBET, and they had been accepted into the program. Students successfully completing the program sit for the national certification test offered by the National Board of Respiratory Care (NBRC). The scores from this test were also used in the study. All statistical analyses were run using the SPSS statistical software. Pearson-Product moment and Eta correlation coefficients are described by using Davis conventions. Descriptive statistics were calculated for each variable. **Results:** A total of 42 student records were used to determine gender, age, high school grade point average, program completion, national certification test, HOBET math, reading, and composite scores. Descriptive data indicated that more than three-fourths of the students in the study were female. Students in the program had an average age of 25.36 ± 7.37 years, an average high school GPA of 2.92 ± 0.58, an average percentage of HOBET math of 64.95 ± 7.85, average percentage of HOBET reading of 54.64 ± 2.97, and an average percent of HOBET composite of 59.26 ± 11.99. More than three-fourths of students completed the program. Those completing the program had an average score of 77.69 ± 7.29 on the national certification test. Pearson product-moment correlation coefficients showed statistical significance between the total high school GPA and all HOBET percentages (Math r=.40, p<.01, Reading r=.41, p<.01, Composite r=.55, p<.01). HOBET reading percentage and composite percentage had a correlation with the national certification test (Reading r=.30, Composite r=.30), although not significant at the p<.01 level. Eta correlations showed a very strong association between total high school GPA, HOBET math, and composite percentage to program completion (GPA r(eta)=.97, Math r(eta)=.86, Composite r(eta)=.83). A substantial association was found between age and HOBET reading percentage to program completion (r(eta)=.64). **Conclusion:** The results indicate that the HOBET should be used to assess student's acceptance and success in the program. High school GPA is valuable in evaluating student's acceptance and success in the program. OF-01-013

WILL RESPIRATORY THERAPISTS GO ONLINE TO SATISFY CONTINUING PROFESSIONAL EDUCATION REQUIREMENTS?

Lynda Thomas Goodfellow, Ed.D., RRT, Georgia State University, Atlanta, GA; Kathy J. Perdue Ph.D., CPA, Atlanta, GA; Thomas Valentine, Ph.D., The University of Georgia, Athens, GA .

Most respiratory therapists (RTs) in the United States are required to complete continuing professional education (CPE). Although Web-based CPE is available, RTs participating in this form of education is minimal. This study examined the perceptions of RTs in the state of Georgia concerning their reasons for participating or not participating in Web-based CPE. Sixteen items with the capacity to motivate or deter participation were ranked. The research question guiding this study was: What is the relative importance of specific reasons that either motivate or deter participation in Web-based CPE by RTs? A survey instrument was developed to address the research question and consisted of 16 motivational items, 16 deterrent items, and 8 personal and professional variables. Reliability scale analysis revealed a coefficient alpha = 0.934 for the motivation scale and a coefficient alpha = 0.905 for the deterrence scale. A sample of 300 RTs was randomly selected from the RCP State Licensure List. In August 2000, the survey was mailed and after two follow-ups, 110 respondents had returned usable surveys for a response rate of 37%. The 110 respondents ranged in age from 24 to 67, with a mean age of 40.1 years. The number of CPE hours completed during the last reporting period ranged from zero to 150 hours, with a mean of 31.8 hours. The majority (65.4%) of respondents were female. Forty-three percent held an associates degree, 34.6% of respondents held a bachelors degree, 6.5% held a masters degree, 0.9% held a doctorate degree, and 9.3% of respondents indicated they held no college degree. At present, only 24 % are using the Web for CPE while 71% indicate that they plan to use the Web for CPE in the future. Means for the motivating items ranged from 3.73 to 5.25 on a 1 (strongly disagree) to 6 (strongly agree) point scale. For the deterring items, means ranged from 2.05 to 3.60. Only 1 item on the deterrence portion of the survey established a mean at or above the 3.5 theoretical half-point. The top motivation items related to time, convenience, and the elimination of travel. The top motivators for using Web-based CPE would allow professionals to schedule CPE on their own time, not during a rigid schedule or out-of-town conference. The deterrence items encompassed concerns about credibility and accuracy of content, and loss of personal interaction. Preferences for traditional classroom education support the literature indicating a resistance to change. The research can assert that RTs are motivated to participate in Web-based CPE and have the confidence, knowledge, and skill capacity to do so. Although the means of individual deterrent items tend to be low, we believe that they work synergistically to dissuade people from participating in education. Dissemination of this information to stakeholders in the continuing education process will allow for successful development of Web-based CPE in the future. OF-01-017

The Relationship Among CO, GPA and Well-being in College Students

A. Faly, N. Spratt, D. Cullen EdD, RRT, FAARC, Respiratory Therapy Program. Schools of Allied Health Sciences and Medicine, Indiana University. Indianapolis, Indiana.

Background: Cigarette smoking is the leading preventable cause of morbidity and mortality in the United States, responsible for more than 400,000 deaths per year. Twenty-nine percent of university and college students currently use cigarettes. Current smoking among college students has increased by 27.8% in a four-year period (1993-1997). Smoking generally permits euphoria and reduces tension and anxiety. Testing exhaled carbon monoxide levels can determine smoking status. Our research question explored whether there was a significant correlation among CO, GPA, and overall well-being in college students. Methodology: We conducted a small pilot study in which we sampled 79 university college students in a large Midwestern urban area at various campus building sites. We used a calibrated Vitagraph Breath CO carbon monoxide analyzer and an original questionnaire to determine GPA, smoking status and general well-being as measured by the Faces Scale (r=.70). This 7-point likert scale consists of stylized faces of happy to sad. Results: Out of the 76 subjects, 43 responded that they had never smoked a cigarette before. Twenty-nine percent of those that were sampled have smoked in the past 30 days. The average smoker began smoking cigarettes at the age of 14. There were no statistically significant correlations between GPA, CO, and the Faces Scale. We did find, however, that CO and GPA could predict how a subject would score on the Faces Scale using regression analysis (6.2399 + (GPA x -3112) + (CO x .0125)). Conclusion: Our study found that among those sampled, 29% actively smoke, which is identical to the rate found among the national average of college smokers. We also found that of the 76 subjects, 43 had never smoked. What we found interesting is that using a regression analysis, we determined a relationship for our dependent variable, the Faces Scale, and our independent variables, GPA and CO. This will allow us to predict the Faces Scale from the GPA and CO although the practical application of student well-being is unsure at this time. OF-01-029

EVALUATION OF NURSES' AND STUDENT NURSES' KNOWLEDGE OF INCENTIVE SPIROMETRY

Amber Mattsey, Alena Graddy, Respiratory Therapy Program, Indiana University, Jo Ann Brooks-Brunn DNS, RN, FAAN, FCCP, Division of Pulmonary, Allergy, Critical Care & Occupational Medicine, Indiana University School of Medicine, Linda Van Scoder, EdD, RRT, Respiratory Therapy Program, Schools of Allied Health Sciences and Medicine, Indiana University, Indianapolis, Indiana.

BACKGROUND The purpose of this study was to evaluate nurses' and student nurses' knowledge of incentive spirometry. This is important because nurses are taking more responsibility in the education and teaching of incentive spirometry to patients. Thus, the evaluation of nurses' knowledge of incentive spirometry was an important area of study. **METHODS** In this descriptive study a self-report survey technique was used for data collection. Convenience sampling was used. Data analysis included descriptive statistics by measures of central tendency and percentages from the scores on the questionnaire. **RESULTS** There were 137 respondents. Scores on the 12-point questionnaire ranged from 4 to 12, with a mean score of 8.52. The questions most often answered correctly concerned patient positioning and the indications for incentive spirometry. The most frequently missed questions concerned the goal and effectiveness of incentive spirometry. The 31 respondents with associate degrees had a mean score of 8.29 on the test. The 10 persons with a Diploma had a mean score of 8.30, and the 36 with bachelor degrees had a mean score of 8.89. The 57 students had a mean score of 8.47, and 3 persons with other degrees had a mean of 8.00. By credential, RN's had the highest mean score, 8.58, while LPN's scored the lowest, 7.80. **CONCLUSION** Comparison of scores based on credential showed that RN's, as a group, scored higher than LPN's. Based on degree, BS nurses scored higher than AS nurses. The study demonstrated that the nurses and student nurses have adequate knowledge of the indications for using incentive spirometry and on proper technique. However, they lack knowledge concerning the goals and effectiveness of incentive spirometry. OF-01-035

AN IN VITRO COMPARISON OF NEBULIZER PERFORMANCE IN NORMAL BREATHING AND ACUTE AIRFLOW OBSTRUCTION
Arzu An, M.S., CRT,CPFT, J.L. Rau Ph.D., RRT, Ruben Restrepo, MD, RRT, Cardiopulmonary Care Sciences, Georgia State University, Atlanta, GA

Introduction. Previous research has shown that different models of nebulizers vary considerably in performance.1 Purpose: The purpose of this study is to compare the performance of different nebulizers in vitro under normal versus simulated emergency department treatment of acute severe airflow obstruction. Methods: Three samples of five different brands of nebulizer (Misty-Neb, Sidestream, Circulaire™, PariLCD, AeroEclipse™) were compared under two different breathing patterns that represent a normal breathing and acute airflow obstruction. Each nebulizer was filled with a 3 ml unit dose of albuterol (Proventil, 2.5 mg), and powered by oxygen at 8 L/min. Nebulizers were connected to the Hans Rudolph Model 1100 Breathing Simulator using a USP throat. Fine particle fraction (FPF)was estimated by collecting drug on a filter between the breathing simulator and the USP throat. Time to sputter was measured using a stopwatch. Drug collected on the filters was analyzed using a spectrophotometer at 276 nm. Results: FPF as a percent of the delivered dose and time to sputter are summarized as means (SD):

	Misty-Neb	Sidestream	Pari LC D	Circulaire™	AeroEclipse™
Normal Breathing					
FPF, %	17.2% (0.4)	15.8% (2.7)	15.2% (4.1)	8.7% (0.9)	38.7% (1.3)
Time, min	11.91 (0.3)	9.51 (0.06)	8.36 (1.18)	7.03 (0.45)	14.44 (1.10)
Acute Airflow Obst.					
FPF, %	16.8% (2.9)	11.4% (0.7)	21.7% (3.3)	5.9% (1.5)	24.6% (1.9)
Time,min	11.92 (0.57)	9.23 (0.20)	8.86 (0.37)	6.00 (0.42)	20.34 (1.78)

There were significant differences of FPF% among the 5 brands, determined by 1-way ANOVA, for both normal ($p<0.001$) and acute obstruction ($p<0.001$) patterns. Conclusion: The nebulizer performance changes in two breathing patterns. This should be considered by respiratory care personnel who make purchase decisions and policies regarding small volume hand held nebulizers. Finally our study is a bench study(therefore, it is necessary to evaluate the clinical implications of our findings.

1. Hess D, Fisher D. Medication nebulizer performance. Chest 1996(110 (2): 498-505.

OF-01-056

RESPIRATORY CARE STUDENT PERCEPTIONS OF PROFESSIONALISM AND AARC MEMBERSHIP

James Lisenbey, R.R.T., Michael Anders, M.P.H., R.R.T., Jennifer L. Shaw, M.A.P., James G. Parker, M.S. Arkansas Society for Respiratory Care; University of Arkansas for Medical Sciences; Baptist Health Medical Center - North Little Rock

Background: Nationwide the rate of student membership in the American Association for Respiratory Care (AARC) is abysmal. In Arkansas, less than one in three students is a member of the AARC. The purpose of this study was to assess student perceptions of the AARC within the context of professionalism.

Method: We surveyed students from 5 Respiratory Care programs in Arkansas. Survey queries featured a 5-point scale and ascertained student perceptions of the AARC and professionalism. We considered responses of "Strongly Agree" and "Agree" as positive; we considered "Strongly Disagree", "Disagree", and "Uncertain" as negative responses.

Results: The entire student population of 5 programs, all within 2 months of graduation, completed the survey. Only 10 of the students surveyed were AARC members. Student valuation of professional issues and the AARC was discordant.

Survey (n-87)	% Positive Response
Therapists should be knowledgeable of new treatments & standards	91
Licensure is important in ensuring competent therapy	83
Research & publication is vital to the future of therapists	82
AARC is a strong advocate in government affairs	65
AARC membership is an important part of being a professional	60
AARC provides adequate continuing education	53
AARC membership cost is fair and reasonable	40
AARC leadership is accessible and addresses my concerns	35

Conclusions: Less than 1 in 8 students, near graduation, were AARC members. While students overwhelmingly valued knowledge of new treatments and standards, research and publication, and licensure as important professional issues, they had an underwhelming valuation of AARC membership, services, and cost. A majority of their negative responses concerning the AARC were "Uncertain", likely representing a lack of awareness about the organization. Our data suggests that we need to raise students' awareness of the AARC's services and role in professional issues in an effort to enhance their perceptions of the organization and membership.

OF-01-068

A PROFILE OF LEARNING STYLE PREFERENCES OF RESPIRATORY THERAPY STUDENTS IN A BACCALAUREATE DEGREE PROGRAM
Tom Smalling, MS, RRT, RPFT, RPSGT State University of New York at Stony Brook.

BACKGROUND: To advance research on learning styles among respiratory therapy students and to provide information to educators for purposes of improving teaching strategies. METHOD: This study profiled the preferred learning style of students based on Kolb's Learning Style Inventory (LSI) (Kolb, 1985). In addition, a comparative analysis was made to ascertain gender and race-related differences in learning style preferences. Forty-two third and fourth-year respiratory therapy students accurately completed a 1-page demographic questionnaire along with twelve questions on learning style preferences from the Kolb LSI. The data were collected and descriptive analysis performed. The twelve ranked questions of the LSI were translated into four cycles of learning: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE). The CE, RO, AC, and AE values were then used to determine the predominant learning style of diverger, assimilator, converger, and accommodator. RESULTS: 37 students were female (88%) and 5 were male (12%). There were 13 Asian-Americans (31%), 12 Caucasians (29%), 7 African-Americans (17%), 7 Hispanics (17%), and 3 Other (7%). The average age of the cohort was 22.3 (SD=2.11) years. The average age of males was 22.8 (SD=2.78) years. The average age of females was 22.3 (SD=1.92) years. The oldest was 30 and the youngest was 20. The results showed that learning occurred in all four learning cycles. The order of learning modes from most used to least used were CE (74.5%), AC (51.5%), RO (47.5%), and AE (33%). The dominant learning modes were then subcategorized according to gender and race. The dominant learning mode remained CE for both females (73.6%) and males (81%). In addition, the dominant learning mode also remained CE for Asian-Americans (74.6%), Caucasians (77.1%), African-Americans (74.1%), Hispanics (67.6%), and Other (80.7%). The two most dominant learning styles were diverger (52%) and assimilator (24%). Only 5% of participants were classified as convergers. 3 out of 5 males (60%) were accommodators and 21 out of 37 females (57%) were divergers. CONCLUSIONS: The majority of the cohort characterized themselves as concrete learners. According to Kolb, (1976) students scoring high in concrete experience (CE) represent a receptive, experience-based approach to learning that relies on feelings-based judgements. High CE people tend to be empathetic. They learn best from specific examples in which cooperation is emphasized. These learners tend to relate to peers, not authority. The data coincides with Belenky et al. (1997) and MacKeracher (1994) studies which suggest that female students place emphasis on relationships, are empathetic in nature, prefer to work in groups (as do divergers) and prefer to learn in an environment where cooperation is stressed rather than competition. The results also coincide with studies by Enns (1993) and Cavanaugh & et al. (1995) showing females to more likely exhibit concrete experience and active experimentation preferences. It is important for educators to be aware of student learning styles and adjust their instruction accordingly. In light of the results, it is suggested that respiratory therapy educators design a curriculum and devise teaching strategies aimed at the dominant learning styles of its students. Respiratory therapy educators need to adapt their teaching to the different cognitive styles, as well as the cultural backgrounds of those students.

OF-01-083

TRACKING CLINICAL EDUCATION USING AN INTERNET DATABASE: EXPERIENCE WITH THE DATAARC™ SYSTEM
Jonathan B. Waugh, PhD, RRT, CPFT; Wesley M. Granger, PhD, RRT. University of Alabama at Birmingham, Birmingham, AL.

Background: Some respiratory care (RC) programs are experimenting with tracking and documenting student progress in the clinical setting using computer databases via the Internet. One such product is DataArc™ (DA), created by the University of Texas Medical Center, Galveston. Method: A baccalaureate respiratory therapy program used feedback from a senior class of 20 students and their seven clinical instructors (CI) to evaluate the DA system. Participants were asked to differentiate between how they rated the DA system and local technical problems that weren't associated with the database. Results: Analyses of the following 5 questions are given in the accompanying table. Question 1; Do you like the idea of computerized record-keeping for clinical education? Ques. 2; DA ease of use? Ques. 3; Reliability of DA? Ques. 4; Problems encountered were due mostly to? Ques. 5; How would you rate DA overall, excluding external difficulties?

Question	Answers	Student#	CI#	Probability
#1	No	5	0	0.023* (χ^2)
	Neutral	7	0	
	Yes	8	7	
#2	Easy	13	5	0.765 (Mann-Whitney)
	Average	7	2	
	Difficult	0	0	
#3	Very reliable	2	5	0.003 (Mann-Whitney)
	Mostly reliable	17	2	
	Mostly unreliable	0	0	
	Very unreliable	1	0	
#4	Hosp. computer	7	2	0.728 (χ^2)
	DA software	10	3	
	Other or none	3	2	
#5	Satisfactory	16	6	0.738 (χ^2)
	Unsatisfactory	4	1	

*At least one cell has an expected value less than 5.

Conclusions: Student and CI group responses differed significantly for questions 1 and 3. Students tended to have greater apprehension toward a computerized record-keeping system for clinical education than their CIs. Although CIs rated the reliability of DA higher than students, all except one person from both groups rated it at "mostly reliable" or better. The majority of both groups rated DataArc as easy to use and no one considered it difficult. There was no one perceived source of problems encountered while using DA that was significantly greater than another. Overall, both groups agreed that the DA system performed in a satisfactory manner. The DA system is a work-in-progress and needs continued, wider evaluation for its proper development and to stimulate development of other clinical education tracking systems.

OF-01-087

PROBLEM BASED LEARNING (PBL) IMPROVES PROBLEM-SOLVING AND DECISION-MAKING SKILLS (PSDMS)

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Background: The medical literature describes PBL as a mechanism for improving students' PSDMS. PBL has been used in health professions education for over 20 years. Evaluation of PBL has revealed that students' PSDMS have improved. Students' cognitive skills are as good or better than those of students taking traditional lecture-lab courses. The purpose of this study was to determine if the PBL component of our Cardiorespiratory Care curriculum at the University of South Alabama has improved PSDMS. **Methods:** A PBL component was established in the curriculum in the fall of 1998. The junior fall semester begins with eight weeks of preparatory lecture and laboratory courses including an introduction to the PBL methodology. In successive semesters, PBL and clinical components for basic therapeutics, intensive care, neonatal/pediatrics, cardiac diagnostics, and subacute care are taught. Beginning in the fall of 1996 and continuing through the spring of 2001, entering juniors and departing seniors completed the Watson-Glaser Critical Thinking Appraisal (CTA). CTA data for two non-PBL classes and two PBL classes were obtained. Since the National Board for Respiratory Care Clinical Simulation Examination (NBRC CSE) is regarded as a test of critical thinking, information gathering (IG) and decision-making (DM) scores for graduating seniors on the secure self-assessment CSE were included in this study. To determine if the non-PBL students were more or less able than PBL students, overall GPAs (OGPAs) at the end of the senior year fall semester were evaluated. Comparisons were made using student's T-test with a p value of 0.05 considered significant. Comments made by the first PBL class on graduate surveys used for accreditation purposes were also reviewed. **Results:**

Dependent Variable	Non-PBL Students (n=32, mean±SD)	PBL Students (n=22; mean±SD)	p value
change in CTA score	-2.75±8.5	-1.59±7.8	0.61
CSE SAE IG score	200.86±17.2	196.14±20.2	0.40
CSE SAE DM score	85.21±18.4	90.50±19.9	0.72
% PASS	34.3	45.0	
OGPA	3.05±0.4	3.04—0.9	0.91

Several year 2000 graduates indicated that they thought their PSDMS were better than those of colleagues who had not experienced a PBL curriculum. The pass rate on the CSE SAE increased, due almost entirely to improved DM scores. **Discussion:** Since the CSE assesses PSDMS, we conclude that PBL has had a positive impact on students' PSMDS. CTA scores may have decreased due to the fact that graduating students take the CTA the same day as the CSE and have many other end-of-program responsibilities. Therefore, students likely dismiss the importance of the CTA, which caused the CTA to be an insensitive measure of PSDMS. No difference in the academic ability of the two groups of students existed, so GPA had no differential influence on CSE or CTA scores. **Conclusion:** Since PBL students have commented that they thought their DM skills were better than those of their non-PBL colleagues and because of the improved CSE SAE pass rate, we conclude that PBL has improved PSDMS. We will eliminate using the CTA and will continue to evaluate the PBL experience using CSE scores for PBL and non-PBL students.

OF-01-127

THE RELIABILITY FOR THE CLINICAL SIMULATION EXAMINATION

Deborah Cullen EdD,RRT, FAARC, Linda Van Scoder EdD,RRT, Indiana University
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The reliability of a test is important to document since it can demonstrate the extent the variations in scores represent systematic differences among examinees rather than testing error.[1] Reliability for credentialing exams is calculated to determine the reproducibility for the test. **Background:** The reliability quotient for the respiratory Clinical Simulation Examination (CSE) has not been reported. The CSE contains information gathering (IG) and decision-making (DM) sections. Historically, the CSE is a unique form of testing with a high re-test rate as well as small differences between first-time and repeater passrates. We questioned whether the CSE is stable and free from testing error. The purpose of this study was to determine the reliability for a representative CSE. **Methods:** A sample of 56 advanced-level respiratory therapy students were administered the 1999 web-version of the self-assessment examination (SAE) CSE form A. These subjects were in their last month of program study and consisted of 30.4% baccalaureate and 69.6% associate degree students from 4 different states. Student examinees were monitored by an instructor to assure simulated test conditions and assist with technical test-taking issues if necessary. All scores were collected and analyzed for Cronbach's Alpha, a measure of internal consistency and intercorrelation among testing items. Numerical computation and analysis were performed with the S-Plus statistical software. Institutional board approval was obtained for this study. **Results:** The reliability for the SAE CSE A was .756 calculated for our sample. Information gathering had a reliability of .724, while the decision-making section revealed an alpha coefficient of .636. **Discussion:** The reliability of the decision-making section was lower than information gathering demonstrating greater variability for scores in the decision-making section. This may account for the high re-test rate among CSE examinees. Similarly, higher information-related history and physical scores were previously demonstrated for the Internal Medicine CSE, which was discontinued in the mid-1980's.[1] Alpha coefficients in the range of .85-1.0 are considered good evidence of reliability.[1] The Clinical Laboratory Scientist credential ranges .90 and higher for their multiple choice test alpha coefficient. An alpha coefficient of .75 is a moderate demonstration of reliability and may account for greater variability in CSE scores. Since the reliability quotient represents the reproducibility or consistency of scores, it is important to demonstrate strong reliability in order to have test validity. However, we caution that these results are limited to the SAE CSE A and may be limited by the student sample or sample size. **Conclusions:** The reliability coefficient of .756 for the SAE CSE A demonstrated that an estimated 25% of the observed variance in scores was due to error in measurement. This error was greater for the decision-making section of the test. These results are limited to the SAE CSE A. We recommend that replication of this study be conducted so that generalizability can be further extended to the respiratory community. We further recommend that the reliability coefficients for all CSE administrations be published.

[1] Swanson DB, Norcini JJ, Gross LJ. Assessment of clinical competence. Assessment & Evaluation in Higher Education. 1987; 12(3):220-46.

OF-01-137

EXAMINATION OF THE REGISTRY CREDENTIAL: ARE THE WRITTEN REGISTRY AND CLINICAL SIMULATION EXAMINATION MEASURING SOMETHING DIFFERENT OR THE SAME THING?

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The Registered Respiratory Therapist (RRT) credential consists of two examinations; the written registry (WR) multiple choice question (MCQ) examination and the clinical simulation examination (CSE). The respiratory profession continues to maintain a two-test process containing the CSE component although no other allied health profession requires a CSE or two tests for one credential.[1] **Background:** Currently, the National Board for Respiratory Care (NBRC) utilizes all content on the certification (CRT) and WR content matrices to produce the CSE. This represents duplication of testing content. The NBRC asserts that the CSE measures problem-solving ability as demonstrated by the differences in passrate between the WR and CSE.[2] A test should be designed to identify minimal knowledge and skills appropriate for the credential. Since the CRT and WR matrices are utilized for the CSE, the content is duplicative. Moreover, the WR tests 73% of its items at the analysis level, which simulates problem-solving ability.[1] Within this context, we set the purpose of this study to determine whether the WR and CSE measure different attributes. Attenuation is utilized for this type of study because it will correct a correlation for its unreliability due to random measurement error and result in a "true correlation" as if both tests were perfectly reliable. **Methods:** A convenience sample of 56 advanced-level respiratory therapy students were administered the 1999 web-version of the self-assessment examination (SAE) WR form B and CSE form A. These subjects were in their last month of program study and consisted of 30.4% baccalaureate and 69.6% associate degree students from 4 different states. Student examinees were monitored by an instructor to assure simulated test conditions and assist with technical test-taking issues if necessary. Reliability coefficients for each exam were determined utilizing Cronbach's Alpha. Spearman Brown attenuation was calculated between the WR and CSE to derive the true correlation between the WR test and CSE. Numerical computation and analysis were performed with the S-Plus statistical software. Institutional board approval was obtained for this study. **Results:** The attenuation calculated a correlation of .857 between the two tests. This result indicated that a strong correlation between the two tests exists. **Discussion and Conclusions**: The strong correlation between the two tests suggests that the WR and CSE measure similar attributes, or at the very least, well correlated content. For our sample, the results demonstrated that the two tests measure the same attributes and that the CSE may not be necessary. Elimination of the CSE would still permit testing for analysis of material through the WR. However, we caution that these results are limited to the SAE WR B and CSE A and may be limited by the student sample or sample size.

[1] Cullen DL & Koss JA. The uniqueness of the clinical simulation examination. Respir Care Education Annual 1999; 8(1):59-68.

[2] Traband MF & George BF. The clinical simulation examination: fact vs. fiction. NBRC Horizons 1994;20(5);1-5.

OF-01-136

THE RELIABILITY OF THE WRITTEN REGISTRY SELF-ASSESSMENT EXAMINATION FOR A STUDENT POPULATION

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Background Reliability, the degree of dependability with which an instrument measures an attribute, is a necessary component of test validity. Unreliable instruments introduce error into the testing process and may result in invalid conclusions being drawn from test scores. Many respiratory therapy educational programs use the self-assessment examinations (SAE's) offered by the National Board for Respiratory Care as a summative measure of their students' competence prior to program graduation. The purpose of this study was to establish the reliability of the written registry (WR) SAE, a 100 question multiple-choice test, for a student population. **Method** We selected a convenience sample of 58 advanced-level respiratory therapy students enrolled in the last semester of programs in four different states for the study. The sample was made up of 17 (29.3%) baccalaureate degree students and 41 (70.7%) associate degree students. Each student completed the web-based Form B of the WR SAE while monitored by an instructor. Scores were collected and analyzed utilizing S-Plus statistical software. We computed Cronbach's alpha, an index of internal reliability, for the WR SAE as a whole by splitting the 100 questions into 17 groups that contained a proportional representation of questions from each subsection of the test (Clinical Data – 17 questions, Equipment – 20 questions, Therapeutic Procedures – 63 questions). This was necessary because subsection items are not evenly distributed throughout the test. The technique we used allowed us to preserve the parallel structure of the subsections used for the calculation of the coefficient. The reliability for each subsection was computed using the split half (even – odd) technique, which was appropriate because each subsection presumably covered the same content. The institutional review board approved the study. **Results** The alpha coefficient for the test as a whole was 0.79. The alpha coefficients for the three subsections were: Clinical Data 0.32, Equipment 0.20, and Therapeutic Procedures 0.72. **Discussion** Alpha coefficients of 0.85 or higher are usually considered to be evidence of good reliability for competence tests.[1] The reliability of the WR SAE for the student group approaches that standard. Using the traditional method for computing Cronbach's alpha (i.e., not splitting the items into 17 parallel subgroups) would have resulted in a slightly lower coefficient (0.77). Our findings are limited to one form of the WR SAE, and the results from our convenience sample may not be generalizable to the entire student population. **Conclusion** The WR SAE approaches good reliability for a student sample. This indicates that the test may meet one of the criteria for validity.

[1] Swanson DB, Norcini JJ, Gross LJ. Assessment of clinical competence. Assessment & Evaluation in Higher Education. 1987; 12(3):220-46.

OF-01-139

THE RELATIONSHIP BETWEEN STUDENT PERFORMANCE ON THE CLINICAL SIMULATION SELF-ASSESSMENT EXAMINATION AND TESTS OF CRITICAL THINKING SKILLS OR CRITICAL THINKING DISPOSITIONS

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Background: Respiratory Therapy programs, and undergraduate degree programs in general, are expected to produce graduates with well-developed skills in critical thinking. We sought to determine whether or not students with better skills in critical thinking, or a positive disposition toward critical thinking, performed better on the Clinical Simulation self-assessment examination (CSE). **Method**: Seventeen senior students in a baccalaureate respiratory therapy program took the California Critical Thinking Skills Test (CCTST) and the California Critical Thinking Disposition Inventory (CCTDI). The CCTST is designed to measure the skills component of critical thinking. The CCTDI is designed to test one's propensity toward thinking critically. The content validity of each is derived from the definition of critical thinking developed by the American Philosophical Association. Approximately five months after completing the critical thinking instruments, the students took the online version of the CSE. The extent of the relationship between the CCTST and CCTDI scores, and the CSE scores was determined by the Pearson's product-moment correlation coefficient (r), with level of significance set at 0.05. The correlations between the CSE subscales (Information Gathering and Decision Making) and each of the CCTST and CCTDI subscales were also determined. **Results**: The Information Gathering portion of the CSE showed a significant correlation with the CCTST total score ($r = 0.555$), the CCTST analysis subscore ($r = 0.501$) and the CCTST evaluation subscore ($r = 0.545$). There was no significant correlation between the Decision Making portion of the CSE and any of the critical thinking tests or their subscales. **Conclusions**: The CCTDI and CCTST are not valid predictors of student performance on the Clinical Simulation Self-Assessment Examination.

OF-01-151

THE EFFECT OF AMERICAN RESPIRATORY CARE PROGRAM ON THE KNOWLEDGE OF TURKISH RESPIRATORY CARE PRACTITIONERS

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Introduction: There is no profession of respiratory therapy nor formal training in the field in Turkey. Respiratory care is taught as a part of the curriculum of physical therapy and nursing and performed by physical therapists, nurses and physicians. Much of respiratory care is learned by nurses and physical therapists as on-the-job training. Lack of formal education threatens the overall quality of respiratory care in Turkey. Faculty in the department of Cardiopulmonary Care Sciences at Georgia State University prepared a four day respiratory care education program at the request of the School of Health Sciences at Koc University in Istanbul, Turkey, to address this lack. **Purpose:** The purpose of this study is to investigate the effect of an American based respiratory therapy education program on the knowledge of Turkish Respiratory Care Practitioners. **Methods:** A total of 37 Turkish respiratory care practitioners who have either nursing or physical therapy backgrounds and attended this four day program participated in this research. Participants took pre and post written multiple choice exams on "Clinical Applications of Respiratory Care" that included questions on Patient Assessment, Basic Modes of Therapy, Mechanical Ventilation, and Case Management. The same exam was used as pre and post in order to compare their scores. The mean values of pre-post test students' scores were compared with a paired student t test. Individual course scores from patient assessment, basic modes of therapy, mechanical ventilation, and case management were reviewed. **Results:** After their attendance at the respiratory therapy program, overall mean score of participants significantly improved from 26.21±14 2 to 44.48±18.4 ($p < 0.001$). **Conclusion:** Attendance at a formal four-day training program in respiratory care techniques and procedures was effective in increasing cognitive performance by participants. Given the lack of emphasis and curricular time on this material in the educational programs of physical therapists and nurses in Turkey, such improvement supports the introduction of formal, specialized training in respiratory therapy for selected caregivers in Turkey.

OF-01-166

FREQUENCY AND IMPORTANCE OF ACLS SKILLS IN ADULT RESPIRATORY CARE. Hoberty PD, EdD, RRT, Fenske S., BS, RRT, and Yokum J., BS, RRT. The Ohio State University Health Sciences Center, The Ohio State University, Columbus, Ohio.
Background. ACLS Provider training has become a part of the educational preparation of the graduate advanced respiratory therapist. However, how often these skills are employed or how important they are in the work setting is not well documented. The purpose of this study was to determine the frequency and importance of ACLS skills for respiratory therapists responding to in-hospital resuscitations in the acute care setting. Further, we wished to determine if there was a difference according to hospital size. Method: We surveyed a sample of 100 acute care hospitals in Ohio by using a written questionnaire. The survey asked department managers to rate each of 17 skills as to frequency and importance in in-hospital resuscitations on a 5 point Lickert-style scale. The sample was stratified into 3 groups according to hospital size. The skills were derived from American Heart Association ACLS Provider Instructor Manual, 1997. Results: 54 respondents returned usable questionnaires. Approximately equal numbers came from each hospital size. The need for ACLS Provider certification was supported by 98% of the respondents, although only 22% indicated that all of the therapists on their resuscitation team were ACLS certified. Based on frequency, 8 skills were determined to be within the current practice of the advanced practitioner. In order of frequency performed they are: recognize lethal heart rhythms on an EKG, recognize major ACLS conditions, recognize non-lethal heart rhythms on an EKG, early management of ACLS conditions, perform endotracheal intubation, suggest ACLS pharmacology, provide defibrillation with a conventional defibrillator, and perform cardioversion with a conventional defibrillator. An ANOVA showed that the frequency of one skill - early management of ACLS conditions - varied by hospital size with therapists in smaller and larger hospitals performing the skill more frequently than those in medium size hospitals. In general, the ratings of frequency and importance did not correlate with one another. Conclusion: Although ACLS merits a position in the training of advanced therapists, more than half of the skills are very infrequently or never used by therapists. The results prompt us to question the need for full ACLS training of all therapists who participate in resuscitations.

OF-01-155

THE EFFECT OF A ONE-DAY ASTHMA EDUCATION SEMINAR ON KNOWLEDGE OF PEAK EXPIRATORY FLOW RATE MEASUREMENT AND METERED DOSE INHALERS WITH SPACERS AMONG HEALTH CARE PROFESSIONALS. Terry S. LeGrand, PhD, RRT, Donna D. Gardner, BS, RRT, and David C. Shelledy, PhD, RRT, The University of Texas Health Science Center at San Antonio, Texas.

Background: Morbidity and mortality among asthma patients have been on the rise in recent years, while availability of health care dollars is declining. In today's managed care environment, it is important for health care professionals to effectively educate patients to better manage this chronic disease. **Objective:** To determine if a one-day asthma education seminar results in enhanced understanding of peak expiratory flow rate (PEFR) measurement and use of metered dose inhalers (MDIs) with spacers among members of the health care team. **Methods:** Physicians (MD; n=12), respiratory therapists (RT; n=13), registered nurses (RN; n=73), and licensed vocational nurses (LVN; n=27) were given a written true/false pre-test on use of peak flow meters and MDI's with spacers followed by a one-day asthma education seminar, consisting of six one-hour lectures and an asthma fair emphasizing use of medications and equipment. Following the seminar and fair the test was repeated, and scores within and between the four groups were compared using paired t-tests and ANOVA, with $p < 0.05$ considered significant. **Results:** Mean scores (SD) are shown in Tables 1 and 2. There were no significant differences ($p > 0.05$) between MDs, RTs, RNs, and LVNs on the pre-test or post-test. When grouped together, posttest scores for all participants (n=125) improved significantly over pre-test scores ($p<0.0001$). When scores were compared by profession, however, only RN's showed an improvement in PEFR measurement test scores ($p = 0.0001$), while all groups improved their scores on MDI/spacer use ($p<0.05$). **Conclusions:** All participants showed a significant improvement in knowledge of the proper use of MDIs and spacers following attendance at the asthma education seminar and fair, though only RNs showed improvement in the use of peak flow measurements. Participation by MDs, RTs, and nurses in a common asthma education seminar is expected to provide consistency in disease management strategies utilized by members of the health care team, resulting in more effective education of patients with asthma.

Table 1. Comparison of pre- and post PEFR test scores by profession

Group	N	Pretest Mean (SD)	Posttest Mean (SD)	p value
All	125	77.44 (12.9)	81.32 (10.0)	<0.0001**
MD	12	77.92 (12.8)	81.25 (10.0)	0.1803
RT	13	82.69 (11.3)	88.46 (4.7)	0.1007
RN	73	77.40 (12.4)	83.49 (8.3)	0.0001**
LVN	27	74.82 (14.5)	82.04 (14.5)	0.0525
		$p = 0.3498$	$p = 0.2203$	

Table 2. Comparison of pre- and post MDI/spacer scores by profession

Group	N	Pretest Mean (SD)	Posttest Mean (SD)	p value
All	125	73.57 (15.0)	84.65 (13.7)	<0.0001**
MD	12	73.2 (16.9)	83.83 (8.4)	0.0218*
RT	13	76.92 (15.9)	90.23 (8.9)	0.0236*
RN	73	73.78 (15.4)	84.94 (14.8)	<0.0001**
LVN	27	71.59 (12.8)	81.52 (14.1)	0.0032**
		$p = 0.7712$	$p = 0.3042$	

OF-01-179

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DEVELOPMENT AND PRELIMINARY OUTCOME OF AN INTERNSHIP PROGRAM FOR RESPIRATORY THERAPY GRADUATES.

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Background: Primary Children's Medical Center (PCMC) is a pediatric and neonatal 250-bed tertiary care center for the intermountain west. The facility has a 55 bed level III NICU and a 29 bed PICU. PCMC is a clinical affiliate for Weber State University's (WSU) Respiratory Care Program. Students that graduated from the program that demonstrated exceptional skills during their clinical exposure were occasionally hired to fill the large number of open positions we have. What we found was that new graduates often lacked advanced intricate problem solving and communication skills needed to function in our high acuity environment. We often turned down new graduate applicants in the hopes of finding RCP's with more neonatal and pediatric experience. The end result was that we had many unfilled positions. Program Development & Design: PCMC designed a respiratory internship program to allow new graduates advanced training in the area of pediatric and neonatal critical respiratory care. WSU is a bachelors prepared program. In the programs fourth year, students are required to take one respiratory elective. Up to this time the electives have been a research project, QA project, and or asthma camp. PCMC proposed to the college that they add the respiratory internship program as another elective option. For students to be considered for the internship program, they must be a CRT, licensed and have BLS. They must have their neonatal and pediatric clinical rotations complete and meet all qualifications at WSU. The internship consists of 36, 12 hour shifts that must be completed in 6 months from the start of the program. The student will be assigned a primary and secondary preceptor. The preceptor is a volunteer staff RCP that is willing to participated in the program. The intern will match the schedule of the preceptors to best suit their schedules. At PCMC we have an assessment team that assesses all patients daily receiving respiratory therapy treatments. The team uses patient assessments, patient driven protocols, and scoring systems to determine the effectiveness of therapy. They suggest alternatives in therapy when indicated. We feel it is important for new graduates to be trained in this area. So, of the 36 shifts, 12 of those will be with an assessment team member. As a student demonstrates proficiency, it is documented, and then they are allowed to perform these tasks without the direct observation of the preceptor. A stipend is paid for each shift worked. At the end of the 36 shifts the internship ends and the intern receives a certification of completion. The intern may or may not then apply of a permanent full or part time position. Discussion & Results: During the program we have the opportunity to observe the students for performance, communication skills, work ethic, time and attendance. This insight provides us with additional information on the intern to determine if they would be a qualified candidate for hire. The preceptors and other staff members appreciated the extra assistance by the work done by the interns. To date, three interns have completed the program. Two applied, and were accepted for permanent full time positions. The other decided not to take a position at our facility. Conclusion: This program allows us to hire new graduates with a higher degree of neonatal and pediatric ICU experience and to fill numerous open positions. This type of program should be considered by high acuity facilities to provide exposure, training and to ultimately hire new respiratory therapy graduates.

OF-01-230

CREATION AND IMPLEMENTATION OF A PATIENT TEACHING PLAN.

Elsie Collado-Koman, BS, RRT, RCP, Lori Taylor, RRT, RCP, Timothy Morris, M.D., UCSD Medical Center, San Diego Ca. **Background:** Education of the hospitalized patient in matters related to the management of their disease at home is of most importance in today's health care environment. Both the scientific content and the actual teaching method may have an impact on the patient's long-term disease management. In order to assure that our practitioners' patient education sessions were accurate and consistent we implemented a department-wide patient teaching plan. **Method:** Home oxygen therapy was chosen as a topic for the initial implementation of the patient teaching plan. A team of respiratory care practitioners was assigned to create a teaching plan for patients being discharged from our hospital on home oxygen therapy. Materials on patient education, techniques on how to design and use patient teaching modules, as well as various reading materials on home oxygen use and devices were distributed prior to each meeting. The team met in four different occasions. The first steps in the creation of the teaching module were to describe the learner (patient) and his/her learning needs, then to establish an educational goal. The overall goal was broken down into specific and attainable objectives. Each objective was assigned an expected outcome, content, teaching packet and evaluation tool. Before being trained in the new patient teaching plan, seventy-eight RCPs were asked to demonstrate how to teach a patient the appropriate use of home oxygen therapy. They then underwent the departmental training program for patient teaching. They were then asked again to demonstrate how to teach patients how to use home oxygen. **Results:** Prior to being trained in the departmental teaching plan, the practitioners used a variety of methods for patient education, most if which were inconsistently presented and difficult to follow and remember. When the patient teaching plan was distributed and the practitioners had the opportunity to rehearse, we observed a more consistent approach to the type of information presented to the patient and evaluation of the learning outcomes. The distribution of handouts followed more defined guidelines and evaluation of each learning outcome was observed before the therapist moved on to the next objective. **Conclusion:** Patient teaching plans provide for more structured and organized patient teaching sessions. They are useful tools for providing continuity and excellence in patient care. Teaching plans, maintained by our education coordinator, are now routinely used in patient education in our department. This program may serve as a model for other institutions interested in improving patient education in disease management.

OF-01-245

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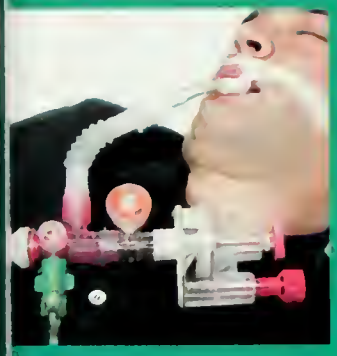

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EVALUATION OF THE WESTMED VIXONE NEBULIZER WITH THE MALLINCKRODT NELLCOR PURITAN BENNETT 840 VENTILATOR

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BACKGROUND: The 840 ventilator is a new model critical care ventilator developed by Mallinckrodt Nellcor Puritan Bennett. The 840 was not designed to accommodate an in-line nebulizer, thus practitioners are required to use metered dose inhalers or external gas powered nebulizers to deliver medications to patients. A simple calculation of Additional Volume = Time x Flow (Lpm/60) is used to assist health care providers in determining the added inspiratory volume. The VixOne nebulizer is one of the newest wet nebulizers on the market manufactured by Westmed. This nebulizer operates at 4 lpm as opposed to the typical 6 to 8 lpm recommended by other nebulizer manufacturers. Our goal was to determine the effects of additional gas flow through the 840 ventilator and determine if the VixOne nebulizer can be used to deliver solution based medications.

METHODS: The study was conducted by utilizing a Mallinckrodt 840 ventilator, VixOne nebulizer, Cosmo Plus Respiratory Profile Monitor (Novametrix Medical Systems Incorporated), a heated-wire ventilator circuit (Airlife), and an adult test lung (Neditester). The Cosmo Plus device was placed in-line between the wye and the test lung to determine precise inspiratory and expiratory volumes from the test lung. The VixOne nebulizer was placed on the inspiratory line of the circuit 6 inches before the wye. The ventilator was set in volume control mode with a ramp waveform. A stiff compliance of 10 ml/cmH20 was used. Inspiratory times were determined by tidal volume and flow rate. Saline was aerosolized in the nebulizer, powered by oxygen at various flowrate intervals. Twenty-five exhaled tidal volumes were recorded at inspiratory times ranging from 0.2 to 2.0 seconds to determine an average tidal volume for comparison. Subsequent liter flows ranging from 1 liter to 15 lpm were then tested.

EXPERIENCE: When adding flow to a circuit during a nebulizer treatment there is an increase in measured expiratory tidal volume and it does not appear to be incremental. As inspiratory times and flow rates increase, the tidal volumes became erratic. The flow rates ranged from 40 to 150 lpm and the tidal volumes ranged from 275 to 730 ml. At flowrates above 8 lpm, we observed expiratory tidal volumes to plateau and high peak inspiratory pressures above 90 cmH2O. Ventilator failure occurred at 13 lpm causing a "severe occlusion" message and the ventilator went into a safety ventilation mode.

CONCLUSION: Based on our research, when adding flow from an external flowmeter during a nebulizer treatment there is an increase in measured expiratory tidal volume and it is extremely variable. The maximum added external flowrate that the 840 ventilator will tolerate is 12 lpm. However based on our observations, flowrates above eight liters per minute could produce less than adequate ventilation. Our data concludes that the additional volume added into the ventilator circuit affects the adequate monitoring of exhaled tidal volumes. Health care practitioners utilizing the 840 ventilator and nebulizers powered by external flowmeters need to be aware of the potential risk of a ventilator failure at flowrates above 8 lpm. The 840 ventilator can tolerate the VixOne nebulizer operating at 4 lpm without any major malfunctions. Future study must be done to determine the efficacy of medication delivery with the VixOne nebulizer and the 840.

OF-01-001

PILOT COMPARISON OF PEAK FLOW MEASUREMENTS: HAND HELD VERSUS A BREATH-ACTUATED NEBULIZERS

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BACKGROUND. Patients suffering from asthma or other reactive airways disease benefit from inhaling medicated aerosols. Hand Held Nebulizers (HHN) deliver aerosol medications during inspiratory and expiratory phases of a patient's respiration. Recently, a Breath-Actuated Nebulizer (BAN) has been introduced that only delivers medicated aerosols only during a patient's inspiratory phase. The aim of the study was to investigate whether using BAN's efficient delivery of medicated aerosols improves peak flow significantly over current practice (using a HHN). METHODS: 40 patients diagnosed with and acute episode of asthma or other reactive airways diseases were randomly assigned to two groups. All patients were out-patients treated at the Allergy Clinic or Emergency Department by RCPs or RNs. One group received medicated aerosols (2.5 mg Albuterol or 2.5 mg Albuterol/.5 mg Ipratropium Bromide mixture) via HHN (Hudson RCI, MICRO MIST®, Temecula, CA). A 6-8 L/min of source gas drove the HHN. The second group received their medicated aerosols, as described above, using a BAN (Monaghan Medical Corporation, AeroEclipse™, Plattsburgh, NY). A 5-7 L/min of source gas drove the BAN in accordance with the manufacturer's product recommendations. Peak Flows were measured, using standard instructions, by the (Dey Laboratories, Astech®, Napa, CA) or (Micro Direct Inc, Micro Plus, Lewiston, ME) at 0 and 10 min. Peak flows at 10 min. were subtracted from the peak flows at 0 min. for both groups. A Student's T-test (one-tailed) was calculated on the resultant differences between groups. RESULTS: 66 treatments were conducted on 40 patients using the research protocol. 19 patients were excluded from the study due to incomplete information. The following table summarizes the result (Mean and Standard Deviation reported in L/min.):

Device	N=	Mean	Std. Dev	P-Value
HHN	17	37.4	50.4	0.31
BAN	30	44.8	46.3	

The individual statistics for the HHN were a mean flow at 0 min. of 222 L/min. and a mean flow of 259 at 10 min. (16.7% improvement). The individual statistics for the BAN were a mean flow at 0 min. of 193 L/min. and at 10 min. 238 L/min. (23.3% improvement). EXPERIENCE: Caregivers seem to prefer BAN for sicker patients with lower initial peak flows. CONCLUSIONS: BAN showed a greater percentage improvement in Peak Flows over HHN. However, the overall difference in the peak flows between the devices was not significant. The results of the study may be limited by caregiver device selection bias, different aerosol medication regimes, and cumulative effect of multiple treatments on a single patient. Furthermore, patients assigned to the two groups many not have had the same degree of responsiveness to aerosol medications.

OF-01-012

The Evaluation of Aerosolized Albuterol Deposition In-line via Conventional Ventilation versus High Frequency Oscillatory Ventilation (HFOV)

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Department of Respiratory Care

Purpose: To our knowledge, there have not been any studies evaluating aerosolized medication deposition with the High Frequency Oscillatory Ventilator (HFOV). We hypothesize that aerosolized medications would be efficiently deposited when given in-line with HFOV. We therefore compared the deposition of albuterol given with Conventional Ventilation versus HFOV in an in-vitro lung model.

Methods: An in-vitro lung model with specially designed filters was developed for this study. We compared aerosolized albuterol deposition with Conventional Ventilation (Bear 1000, Bear Medical Systems, Inc, Riverside, CA) and HFOV (3100A, Sensormedics, Yorba Linda, CA) at two separate sites in the lung model. The first set of data was collected 2 cm distal to a #8 ETT that represented the carina. The second set of data was collected 6 cm to the left and right of a bifurcation (90° angle) in the model that represented right and left mainstem branches. Ten small volume nebulizers (Misty-Neb Nebulizer, Allegiance, McGaw Park, IL) were administered with 3 mls of albuterol (Warrick Pharmaceuticals, Reno, NV) containing a total of 1.5 milligrams at 7 lpm for 7 minutes for each site and each type of ventilator. Bias flow on the HFOV was reduced when additional flow from the nebulizer was introduced so that mean airway pressure was unchanged. After each nebulizer was completed, the filters were removed from the circuit and dissolved with 6 mls of ethanol in a sterile container. Samples from each container were then analyzed with a spectrophotometer at 278 nm to calculate albuterol deposition amounts.

Results: Deposition amounts in milligrams:

Filter location	Conventional Ventilator (Bear 1000)	HFOV (Sensormedics 3100A)
Carina	**Mean**- .1249 **SD**- .01539 **Range**- (.109-.147) **% Deposited**- 8.3%	**Mean**- .2141 **SD**- .05866 **Range**- (.053-.250) **% Deposited**- 14.3%
Left Mainstem	**Mean**- .0807 **SD**- .00532 **Range**- (.075-.089) **% Deposited**- 5.4%	**Mean**- .0781 **SD**- .00647 **Range**- (.068-.090) **% Deposited**- 5.2%
Right Mainstem	**Mean**- .0844 **SD**- .00581 **Range**- (.076-.093) **% Deposited**- 5.6%	**Mean**- .0838 **SD**- .00469 **Range**- (.075-.091) **% Deposited**- 5.6%

Conclusion: Studies have shown that when nebulized aerosols are given in-line with conventional mechanical ventilation, approximately 1.5-15% of the medication is deposited in the airways. We found that aerosolized medication given in-line with HFOV using a specially designed adapter will result in similar findings. We feel that patients who are on HFOV and have been diagnosed with hyper-reactive airway disease would benefit from this data.

OF-01-022

DELIVERY OF HELIOX FOR STATUS ASTHMATICUS UTILIZING PARATREND 7® CONTINUOUS BLOOD GAS MONITOR .

Clifton Dennis, RRT, Dr. Lynn Coule, M.D. Medical College of Georgia, PICU

Heliox is used to treat asthma that is unresponsive to conventional therapy (1,2). There is published data indicating that heliox is effective in lowering Pulsus Paradoxus and increasing peak flow (1). As well as decreasing PaCo2 and increasing pH (2). We monitor airway pressures due to the decreased volume of Heliox delivered when utilizing the SV300 (3). In this particular case we utilized the Paratrend 7 intra-arterial continuous blood gas monitor to continuously monitor acid-base and oxygenation status. The Paratrend 7 has been shown to be effective in the pediatric population. (4) A 9-month-old black male was referred to our institution for pediatric intensive care management of acute status ashtmaticus that was refractory to conventional management that included continuous nebulized bronchodilators and oxygen therapy. This patient was a known asthmatic with uncontrolled asthma; he had had three prior hospitalizations in the previous year for asthma none requiring intubation. He was placed on Pressure Regulated Volume Control, He received continuous nebulized albuterol, intravenous terbutaline, magnesium, systemic corticoidsteriods. A femoral arterial catheter was placed to monitor blood pressure and provide continuous blood gases via the Paratrend 7. This patient had limited response to bronchodilator therapy and adjunct therapy. Since this patient had increasing peak airway pressures and a worsening respiratory acidosis. It was decided by the care team to try heliox via a SV 300 ventilator in an attempt to decrease the peak airway pressures as well as to decrease the respiratory acidosis. Throughout all interventions continuous blood the Paratrend 7 provided gas monitoring. Within 1 hour after initiation of heliox there was a dramatic decrease in the Pco2 and an increase in the pH . On day five this patient was discharged to the pediatric general care floor where he was eventually discharged home in his normal sate of health.

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OF-01-043

Analysis of Clinical Characteristics and Drug Sensitivity Tests of Lower Respiratory Tract Infection by *Xanthomonas Maltophilia*

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Objective to analyze the clinical characteristics of lower respiratory tract infection caused by *Xanthomonas maltophilia* and to investigate the antibiotic sensitivity of *Xanthomonas maltophilia* strains. **Methods** Retrospective study of the clinical data of 54 cases with lower respiratory tract infection by *Xanthomonas maltophilia*, including risk factors of morbidity, clinical symptoms and signs, x-ray findings, blood routine test, treatment and prognosis. Drug sensitivity against strains of *Xanthomonas maltophilia* by K-B method was studied. **Results** There were 39 males and 15 females, the mean age being 51±17 years. 87% of the cases had underlying diseases, most of which were COPD complicated by respiratory failure. 57% of the cases were immunocompromised. 39% of the cases were in ICU of CCU. 54% of the cases accepted invasive treatments, and 93% of the cases were given broad-spectrum antibiotics. Clinical manifestations include chill (72%), fever (80%), cough (94%) and expectoration (91%). The chest x-ray revealed infiltration in lower lobes of both lungs. 16 cases had consolidations, and 11 cases were complicated with pleural effusions. The drug sensitivity test in vitro showed that these strains were multiresistant to commonly used antibiotics, and drugs whose sensitive rate were over 50% included SMZco, ceftazidine, and timentin. **Conclusions** The lower respiratory tract infections caused by *Xanthomonas maltophilia* develop in patients with various underlying diseases, especially in the immunocompromised patients. Risk factors of morbidity were; patients in ICU of CCU, acceptance of invasive treatment and, inappropriate use of broad-spectrum antibiotics. Clinical manifestations include severely toxic symptoms and some cases had pulmonary consolidations and pleural effusion.

OF-01-052

Direct, Rapid Detection for Rifampin Susceptibility to M. Tuberculosis

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Objective To evaluate the use of molecular biotechnology for direct, rapid detection of rifampicin-resistance mutations in M. tuberculosis. **Methods** 45 M. tuberculosis clinical isolates and 70 sputum samples were tested by polymerase chain reaction-single stranded conformation polymorphism (PCR-SSCP) technique. M. tuberculosis strain H_{37} Rv was used as control and compared with the result of susceptibility test. DNA sequencing was also performed in some of the strains. **Results** All tested susceptible isolates displayed identical SSCP patterns. Of 29 RFP resistance strains, 26 (90%) had distinct mobility shifts that can be discriminated from susceptible isolates. 9 sputum samples which were successfully evaluated by PCR-SSCP showed concordant result acquired from BACTEC 460 method. As the result of DNA sequencing, it was observed that seven RFP-resistance phenotype of M. tuberculosis strains had missense mutation, in which 5 isolates displayed TCG?TTG or CAC mutations at codon 531, 2 had CAC?TAC mutation at codon 526. On the other hand, one strain which was susceptible to rifampin exhibited identical nucleotide alignment to be sequence of rpoB gene. **Conclusions** RCR-SSCP could be used as a method for simple, rapid, and reliable detection of rifampicin-resistance mutations in clinical samples of M. tuberculosis.

OF-01-053

LEVALBUTEROL (LEV) AFFORDS SUPERIOR HEALTH AND COST BENEFIT OVER RACEMIC ALBUTEROL (RAC) IN THE EMERGENCY DEPARTMENT (ED). Deb Haider, RPFT, CRT, RCP North Memorial Medical Center, Minneapolis, MN 55422

RAC, the most common β_2-agonist bronchodilator used in the treatment of acute asthma exacerbation, is comprised of 50:50 mixture of (R)- and (S)-albuterol; however, only (R)-albuterol (levalbuterol) provides bronchodilatory activity. This study compared LEV and RAC for the treatment of acute bronchoconstriction from primary asthma in the ED. Patients (≥12 years of age) were administered either RAC (n=30) or LEV (n=24). Atrovent® was administered concomitantly with the first dose of either β_2-agonist but then only as subjectively necessary. Mean initial PEF (L/min) and FEV_1 (L) were measured in a subset of RAC (n=16) and LEV (n=13) patients and were similar between the treatment groups (PEF, 209.2 vs. 208.6; FEV_1, 1.21 vs. 1.17). Pulmonary function improved in patients administered either β_2-agonist, however, the extent of improvement was greater among LEV patients compared to RAC patients (%ΔPEF, 68% for LEV vs. 46% for RAC; $\%\Delta FEV_1$, 70% for LEV vs. 34% for RAC). Greater bronchodilation was achieved with lower total amounts of LEV (3 mg/patient) compared to RAC (11.5 mg/patient). In addition, total Atrovent amounts utilized were ~3-fold lower in LEV patients (0.45 mg) compared to RAC patients (1.5 mg). LEV patients experienced decreased heart and respiratory rate suggesting resolution of hypoxia and reduced anxiety. In contrast, RAC patients showed increased heart rate and less of a decrease in respiratory rate. Also, decreased incidence of β_2-agonist-associated side effects (tremor, nervousness, tachycardia, dizziness, nausea, cough and headache) were observed in LEV patients compared to RAC patients. Twenty percent of RAC patients were admitted to the hospital subsequent to ED therapy, while 12% of LEV patients were admitted. Length of hospital stay was 35 hours for RAC patients and 23 hours for LEV patients. Despite the higher cost of LEV ($1.54/unit dose) compared to RAC ($0.30/2.5 mg unit dose; $0.60/5.0 mg unit dose) and Atrovent ($1.12/0.5 mg unit dose); the total cost of bronchodilator therapy between the two groups was similar ($4.89 and $4.23 for LEV and RAC, respectively). This resulted from fewer LEV and Atrovent administrations necessary to achieve bronchodilation. These data suggest that LEV, compared to RAC, is a clinically superior bronchodilator, decreases β_2-mediated side effects, improves clinical outcomes, and provides cost efficient asthma management in the ED. OF-01-069

MULTI-DRUG RESISTANT STREPTOCCOCUS PNEUMONIAE IN A SUBACUTE FACILITY

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Purpose: Multiple drug resistance has become a problem in long-term care facilities. We describe multiple drug resistance in *Streptoccocus pneumoniae* from tracheal aspirates at a long-term care facility. **Methods:** Patients are from a 50-bed, freestanding, pediatric subacute facility for tracheostomy dependent patients (ventilator and non-ventilator dependent). Tracheal cultures obtained for body temperature greater than 38.3°C, change in respiratory status or change in secretions (thick, green). Minimal inhibitory concentrations (MIC) were determined by e-test for penicillin and ceftriaxone. **Results:** 221 cultures, 25 (11%) were positive for *Streptoccocus* from 17 patients.

Antiobiotic	Resistance (MIC in mcg)	Specimens n(%)
Penicillin	≥ 2	19 (76%)
Penicillin	≥ 4	4 (16%)
Ceftriaxone	≥ 1.0	15 (60%)
Ceftriaxone	≥ 2.0	5 (20%)

Patients treated with 1-3 days of ceftriaxone followed by 2-3 weeks of amoxicillin. There were three clinical and microbiological failures requiring re-treatment. One patient with hereditary spherocytosis required four courses of therapy. **Conclusion:** Multiple drug resistance is a problem in long-term care facilities. Ceftriaxone and oral antibiotics were effective to treat respiratory infections, though relapses did occur. **Clinical Implications:** Multiple antibiotic resistance of *Streptoccocus pneumoniae* can occur in long-term care facilities. MIC may help guide therapy.

OF-01-092

A BENCH COMPARISON OF FOUR NASAL CPAP PASSOVER HUMIDIFIERS

J. Lewarski, BS, RRT, G. Austin, Eng., RC Medical, Inc. and TAGA Medical, Inc., Ohio.

Background: Nasal continuous positive airway pressure (CPAP) is an accepted treatment for individuals with moderate to severe obstructive sleep apnea. Previous studies show that patient compliance with CPAP treatment can be as low as 45%. The studies suggest there are a number of primary contributors to low patient compliance, including oro-nasopharynx drying. Providing humidity in-line to the CPAP delivery system is the standard treatment. Although a number of CPAP humidifiers are available, there is limited information regarding performance. The purpose of this study was to compare the humidity outputs of 3 commercial and one prototype CPAP humidity systems. **Methods:** We studied 3 commercial non-heated passover style humidifiers and one manufacturer's molded prototype (TAGA Velocity®). Using a Respironics Bi-PAP® S/T as the flow generator, standard 18 inch and 6 foot smooth bore tubing, a flow resistor with a leak placed distal to the flow generator, mimicking mask CPAP, and a calibrated hygrometer, we measured relative humidity (RH) levels at the patient interface. Ambient temperature and humidity levels were recorded prior to the start of each phase of the testing. CPAP generator output humidity measurements without a humidifier in-line acted as the baseline for each test. A 5-minute stabilization period was maintained before sampling output humidity. Pressure and flow settings were selected to represent a typical range of CPAP pressures used in clinical practice. Pressure and flow was verified using a Timeter analyzer, model RT-200. The increase in mean output RH over ambient was compared using repeated measures ANOVA. Pairwise multiple comparisons were performed with Tukey test. **Results:** Data represent the mean of 3 complete measurements/unit.

CPAP Pressure & Flow Rate	Humidifier	Ambient Temp. °F	Ambient R.H.	Output R.H.	Increase in R.H. Over Ambient
10 cmH2O ~90L/min	TAGA Velocity®	70.9	47.4	75.8	60.1%
	Respironics Oasis® 532053	69.9	47.1	72.5	54.1%
	ResMed 18815/1	70.7	48.4	73.9	52.6%
	Nellcor Puritan Bennett S-616386-00-A	71.0	47.9	63.6	33.0%
15 cmH2O ~130L/min	TAGA Velocity	73.3	40.3	73.7	83.1%
	Respironics Oasis® 532053	71.5	42.8	70.6	65.9%
	ResMed 18815/1	72.7	41.5	67.6	63.3%
	Nellcor Puritan Bennett S-616386-00-A	72.5	41.2	58.03	33.0%

The TAGA unit demonstrated a significantly higher humidity gain compared to all other units ($p < 0.004$). The Respironics unit had a higher gain than the ResMed and Nellcor units ($p < 0.05$). Pressures/flows measured at patient interface were consistent to those measured at the outlet of the CPAP generator, showing that the humidifiers created little back-pressure. **Conclusions:** All devices tested increased the output humidity levels. Units with a baffling system (TAGA & Respironics) consistently performed better than non-baffled units. Further research is needed to established standards for CPAP humidification testing and to determine the effects of humidity use on patient complaints and overall nasal CPAP compliance.

OF-01-111

ANALYSIS OF CROSS-CONTAMINATION OF METERED DOSE INHALERS WHEN USING THE RESPIRONICS OPTICHAMBER UNDER THE COMMON CANISTER PROTOCOL.

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Introduction: Many respiratory therapy departments have implemented the common canister protocol (ccp) as a cost-saving mechanism. The purpose of this study was to investigate the safety of administering MDI medications among patients when using the Respironics OptiChamber under the ccp. Methods: Data were collected from patients receiving MDI medications at the University of South Alabama Knollwood Park Hospital (USAKPH), a 250-bed teaching hospital where the ccp is used. The study involved surveillance of a sequence of three specimen collections obtained from each patient. Specimen collections (specimens A, B, & C), obtained on BBL™CultureSwabs™ were cultured on two different media: sheep's blood and chocolate agar, and analyzed for growth at 24, 48, and 72 hours of incubation. Specimen A was obtained from the MDI mouthpiece following swabbing with an alcohol pad before the MDI mouthpiece was attached to the OptiChamber. Specimen B was obtained from the same location after the MDI mouthpiece was removed from the OptiChamber, following the administration of the medication. Specimen C was obtained from the MDI mouthpiece after swabbing it with an alcohol pad following the removal of the MDI mouthpiece from the OptiChamber. MDI medications administered included Ventolin (albuterol), Atrovent (ipratropium bromide), Flovent (fluticasone), and Serevent (salmeterol). Patients who were in isolation or receiving mechanical ventilation were not included in this study. Results: The sample subject profile included a total of 50 patients. The 150 (50 patients x 3 cultures/patient) cultured samples demonstrated no growth at 24, 48, and 72 hours of incubation. Conclusion: Cross-contamination using MDIs among patients in conjunction with the Respironics OptiChamber under the ccp did not occur. Therefore, the ccp is a safe method for administering medications via MDIs using the Respironics OptiChamber. A significant reduction in purchase costs of MDIs is also possible when implementing the ccp. For example, the University of South Alabama Medical Center, which does not use the ccp and spends about $36,144.00/year on MDI medications, would save approximately $19,879.00/year using the ccp.

OF-01-122

PERFORMANCE CHARACTERISTICS OF THE SERVO 345 USN IN PEDIATRIC MECHANICAL VENTILATION

William W. Quinn RRT RPFT, Regina Brzak, Cheryl Kennedy CRT, Cape Fear Valley Health System Fayetteville, NC. We sought to determine the rate of medication consumption, efficiency of drug delivery, and quantity and concentration of residual medication in a bench model of pediatric volume ventilation while using the Servo 345 ultrasonic medication nebulizer (USN). Methods: A Servo 300 ventilator was attached to a 3.0 mm endotracheal tube, with a drip trap attached to the end. An adapter containing a cotton ball was attached between this and a standard 1ml/cm H2O infant test lung. The USN was operated with 2.5 mg albuterol in 3 ml solution in a position 10 cm upstream from the patient wye for thirty minutes. The USN was weighed before and after each run to determine rate of nebulization. A fresh cotton ball was washed at the end of each run with 20 ml saline. The washing was examined by spectrophotometry to determine albuterol content as a percent of albuterol placed in the USN. The residual medication in the USN was also assayed. Ten trials were done in SIMV Volume Control first with a rate of 40, a 50 ml tidal volume, 33% I-time, 5 cm H2O PEEP and 100% O2. Then ten more were done with the rate turned down to 20. Results (SD): Medication nebulized in 30 minutes: Rate 40: 2.21ml(.23) Rate 20: 1.66ml(.20). Percent drug delivered to test lung: Rate 40: 3.6% (.9) Rate 20: 3.2%(1.1) Concentration of residual medication left in USN compared to original drug: Rate 40: +17%(5) Rate 20: +7%(7). Conclusions: Under the conditions tested the USN will leave residual medication which is more concentrated than the original medication, in a manner very similar to a jet nebulizer. The percentage of drug delivered to the test lung is also similar to that reported from similar tests using jet nebulizers. Finally, at a rate of 40 the rate of nebulization of medication was .17 ml/min per 0.1 liter/sec flow (2.21 ml in 30 min with 2 liter minute volume plus .67 liters expiratory bias flow), not the .1 ml/min predicted by the USN operator's manual

OF-01-129

PARI VS. SIDESTREAM NEBULIZER COMBINED WITH TWO COMPRESSORS FOR AEROSOLIZATION OF PULMOZYME®

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Background: Pulmozyme (rhDNase) is a nebulized drug that reduces sputum viscoelasticity in patients with cystic fibrosis. Pulmozyme delivery with the SideStream (SS) nebulizer powered by the powerful Invacare MobilAire (MA) compressor resulted in greater increase in FEV1 than the Hudson T-Updraft/PulmoAide combination(1), probably due to the smaller droplet size which may reach smaller airways. However, the MA is expensive (not always covered by third party payors), and the SS may waste significant drug due to the mouthpiece design and the constantly open venturi. Our hypotheses were 1) breath-enhanced nebulizers produce more drug in the fine particle range than SideStream, and 2) the more powerful MA compressor changes the performance of nebulizers. We evaluated the amount of Pulmozyme delivered by three different nebulizers: Invacare Sidestream (SS), PARI LC STAR (LC*), and PARI LC+ (LC+) when powered by two different compressors: the MA and the PARI PRONEB ULTRA (PNU).

Methods: Each nebulizer was charged with 2.5 ml Pulmozyme (1mg/ml). For each nebulizer/compressor system, we measured the Mass Median Diameter (MMD) and the respirable fraction (% RF = particles < 5 microns) using laser diffraction (Malvern Spraytec). We additionally measured the total "inspired" dose of drug captured on a filter during simulated breathing, and calculated the respirable drug dose (RDD), i.e. the product of the %RF and the total inspired dose. Breath simulator settings were rate of 18 breaths per minute, tidal volume of 500 ml, I:E ratio of 1:1.5. Duration = time during simulated breathing from the beginning of nebulization until 1 minute past the onset of sputter. Pulmozyme was assayed with spectrophotometry. We studied 3 nebulizers of each type in duplicate for both the laser and breath-simulation studies.

Results:

Neb/Compressor	MMD (microns)	%RF	Inspired Dose (mg)	RDD (mg)	Duration (minutes)
SS/PNU	3.45 ± 0.13	70.8 ± 2.2	0.17 ± 0.09	0.12 ± 0.06	4.19 ± 0.2
LC*/PNU	3.36 ± 0.18	68.2 ± 2.8	0.68 ± 0.10	0.47 ± 0.06	7.16 ± 0.3
LC+/PNU	5.19 ± 0.26	48.7 ± 1.9	0.46 ± 0.10	0.22 ± 0.04	5.61 ± 0.4
SS/MA	1.84 ± 0.19	90.8 ± 2.6	0.14 ± 0.05	0.12 ± 0.04	3.84 ± 0.7
LC*/MA	2.06 ± 0.07	84.9 ± 1.4	0.43 ± 0.02	0.37 ± 0.01	4.53 ± 0.2
LC+/MA	2.95 ± 0.05	69.5 ± 0.8	0.35 ± 0.08	0.24 ± 0.05	3.99 ± 0.2

Discussion: The SS produced an aerosol with an equal or smaller MMD and higher %RF vs. LC+ or LC* with either compressor. The MA compressor reduced treatment times and MMD, and increased %RF for all three nebulizers. However, RDD takes into account not only %RF but also the efficiency of the device, and is a more relevant measure for comparison of different nebulizer/compressor systems. The RDD for the LC+ and LC* were 2-4 times higher with either compressor than that of the SS. Despite reducing the MMD, the MA did not improve RDD (dose available to the lung) for the SS or LC+, and resulted in less drug being delivered by the LC*, due to increased waste during exhalation and increased dead volume in the nebulizers.

Conclusions: Though the SS nebulizer and the MA compressor each produced small particles in a short time, they had large drug losses during exhalation and high dead volume. The LC+/PNU and LC*/PNU are less costly and produce 2-4 times more respirable Pulmozyme than the SS/MA(1).

OF-01-130

1) Geller DE, Pediatr Pulmonol, 1998; 25: 83-87

COMPARISON OF PRESSURIZED METER DOSE INHALER (pMDI) TECHNIQUE IN TWO PEDIATRIC SPECIALTY CLINICS.

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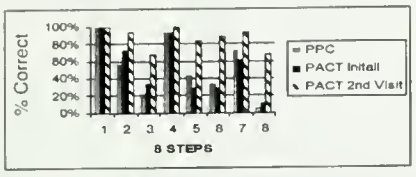
INTRODUCTION: Asthma is the most common chronic disease of childhood affecting an estimated 4.8 million children. Routinely, inhaled medications are prescribed for prevention and rescue therapy. Many forms of delivery systems are available for the inhalation route. Proper use and compliance with taking all medications is important to ensure adequate control of symptoms. A Pediatric Asthma Compliance and Technique (PACT) Clinic was established with one of its primary goals to form a simple but effective asthma plan consisting of medications given by the pMDI. **METHODS:** Thirty six pediatric asthma patients on inhaled medication were evaluated for proper use of pMDI technique according to the 1997 NHLBI *Guidelines for the Diagnosis and Management of Asthma*. The case control study consisted of 18 patients from an established Pediatric Pulmonary Clinic (PPC) and 18 patients from the PACT clinic. The groups were similar in age, PPC mean 10.89 (range 6-17), PACT 9.94 (6-17) and prebronchodilator FEV_1, PPC mean 88.5% (52-125%), PACT 85.2% (59-103%). Each patient needed to be seen a minimum of two times for analysis. The only difference being that in the PACT clinic all patients were evaluated for technique on their initial visit. After allowing the patient to demonstrate the technique without prompting, a thorough review and demonstration was performed by the respiratory therapist. Each unsuccessful step was highlighted on a patient education hand out and given to the patient. **RESULTS:** On average both groups performed a median of 4/8 (50%) of the steps correctly on the initial evaluation. No one was able to perform all steps satisfactory. On the second visit, the PACT patients performed a median of 7/8 (88%) (range 4-8) steps correct, with 5/8 steps performed significantly better than their PPC counterparts ($p \leq .02$, sign test). With success being 8 correct steps, the PACT group had 6/18 (33%) patients who could performed all 8 steps correct as compared to the PPC patients ($p .031$).



CONCLUSION: After one intense education session, the PACT patient demonstrated a greater success rate as compared to their counterparts. Even in an established Pediatric Pulmonary Clinic one can not assume that proper pMDI technique was taught to the patient and therefore routine competency testing on the proper use of the inhaled medication is important to ensure adequate medication delivery.

OF-01-158

A COMPARISON OF THE USE OF LEVALBUTEROL COMPARED TO RACEMIC ALBUTEROL IN THE PULMONARY STEPDOWN POPULATION

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HYPOTHESIS: Racemic Albuterol consists of both an R-isomer and an S-isomer. The R-isomer is responsible for bronchodilation. The S-isomer was originally thought to be inert, but recent evidence appears to relate it to unwanted side effects. Levalbuterol is a new preparation that contains only the R-isomer and has a longer duration than racemic albuterol. We hypothesized that routine use of levalbuterol administered TID would require fewer overall as well as PRN treatments than racemic albuterol administered QID.
METHOD: The study design was a three month observational period using levalbuterol TID + prn instead of racemic albuterol QID + prn as the standard beta agonist bronchodilator therapy on our pulmonary step-down unit. The same three month period during the previous year when racemic albuterol was the standard beta agonist bronchodilator therapy was used as a historical control period. Total and prn treatments/patient were calculated during both periods and compared using unpaired T tests.
RESULTS: The total number of treatments decreased from 3835 during the control period to 2613 when Levalbuterol was used (3.5 treatments per patient day and 2.8 treatments per patient day respectively – $p < 0.05$). The number of PRN treatments declined from 540 during the control period (Racemic Albuterol) to 375 during the levalbuterol period (0.5 prn treatments and 0.4 prn treatments per patient day respectively - $p < 0.05$).
CONCLUSION: Levalbuterol 1.25 mg delivered on a TID + PRN basis results in fewer PRN treatments per patient day as compared to the Administration of Racemic Albuterol 2.5 mg QID +PRN.

Note: Sponsored in part by Sepracor.

OF-01-169

Bench Evaluation of the HUMAX Heated Humidifier

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BACKGROUND: Heated humidifiers used during mechanical ventilaton should deliver a minimum absolute humidity of 30 mg/L of water at 33 ± 2° C (Respir Care 1992; 37(8):887-90). We evaluated a pre-production prototype humidification system (Humax, Respironics Inc) that uses a heated wire wrapped with a braided bundle of hollow-core water-filled microporous fibers in the inspiratory limb of the breathing circuit. Tests were conducted simulating continuous and intermittent flow conditions.

METHODS: Heater temperature was set to 37°C for all tests. Each test was 10 minutes in duration and performed in triplicate. A hygrometer (HM34, Vaisala) measured temperature (T_{hygro}) and relative humidity (RH) six inches from the wye on the inspiratory limb ~2 inches distal to the humidifier thermister (T_{heater}). Measurements of T_{heater}, T_{hygro} and RH were taken each minute of the test. Absolute humidity (AH) was calculated for each data point as the product RH and the maximum humidity level for a given temperature. Continuous flows of 5, 20, 40, 60, 80, and 100 L/min, delivered via a calibrated flowmeter, were studied. Intermittent flow conditions consisted of 2 studies using a PB-840 ventilator (Carlsbad, CA). *Study 1:* An I:E of 1:2 was used with the following VT times rate combinations: 0.1 L*40; 0.2 L*20, 0.5 L*20, 0.9 L*20 and 0.9 L*30. *Study 2:* A VT=0.9 L and RR=20 with a decelerating inspiratory flow of 30, 60, 90 and 120 L/min, resulting in an I:E ranging from 1.5:1 to 1:5.3.

RESULTS: T_{heater} was 0.5-2°C < T_{hygro} for the initial 1-2 minutes, then $T_{heater} > T_{hygro}$ by 0.5 – 2°C until study end during all tests. Continuous flow: RH reached 100% by minute-1 in all tests. The system could not maintain temperature & RH at 100 L/min; system was shut down and reset every 5 minutes. The table shows how quickly a temperature of 33 was reached, temperature and AH at which the system plateaued and time to attain plateau.

Tested Flows (L/min):	5	20	40	60	80	100
Time to T_{hygro} = 33°C (min)	2	4	6	5	8	-
Plateau T(°C)/time (min)	35.5/7	36.5/8	36.4/9	35.4/9	33.1/8	30.0/3
Plateau AH (mg/L)/time (min)	41 3/9	43.0/8	43.0/8	40.0/8	31.0/7	25.0/3

Intermittent flow: *Study 1*- In all tests, T_{hygro} >33°C by minute-5, RH=100% by minute-1, AH >30 mg/L by minute-3 to 4 and plateaued near 44 mg/L at minute-8. *Study 2*- In all tests, T_{hygro} >33°C by minute-5, RH=100% by minute-1, AH >30 mg/L by minute-2 and plateaued near 44 mg/L at minute-8

CONCLUSION This system was very efficient in heating and humidifying all but extreme conditions; reaching target temperature within 2-10 minutes and target RH within 1-2 minutes. A possible limitation of the study was the short duration, although preliminary testing demonstrated that the system maintained temperature and RH once a plateau was reached for the duration of an extended observation period (>4 hrs). A comparison against other heated humidifiers is warranted.

OF-01-174

This study was funded by Respironics Inc.

EVALUTION OF A NEW IN-LINE COLLAPSIBLE HOLDING CHAMBER (CHC) FOR DELIVERY OF INHALED MEDICATIONS TO THE MECHANICALLY VENTILATED PATIENT

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Background: Delivery of medications from pressurized metered dose inhalers (pMDIs) to mechanically ventilated patients is complicated by the presence of the endo-tracheal tube (ETT) as well as by 'rain-out' of condensed water vapor, both of which make it more difficult to deliver the therapeutically beneficial portion of the dose contained in particles < 4.7 µm aerodynamic diameter to the patient. The AeroVent™-II collapsible holding chamber ((CHC), Monaghan Medical Corp., Plattsburgh, NY) has been re-designed to optimize transport of pMDI-delivered aerosols. It is intended to remain collapsed in-circuit when not in use, and is expanded whilst aerosol therapy is being delivered.
Methods: We compared the *in vitro* performance of a group of AeroVent™-II CHCs (n=5 devices) for the delivery of a short-acting bronchodilator (Proventil™-HFA 108 µg albuterol sulfate ex actuator mouthpiece of the pMDI, Key Pharmaceuticals, Kenilworth, NJ) in both a dry (T=24°C/RH=50%) and humidified (T=34°C/RH=100%) adult ventilator circuit. Tidal breathing (750-ml) was simulated with inspiratory/expiratory ratio of 1:2 and rate ca. 15 breaths/min by means of an Infrasonics Adult Star® 1500 ventilator. The CHC was located in the inspiratory limb of the ventilator circuit. Filter collection at the distal end of a 8-mm diameter endo-tracheal tube was used to assess total emitted dose (TED_{vent}). In a parallel study conducted at room ambient conditions, the AeroVent™-II CHCs were connected directly to the induction port of an Andersen 8-stage cascade impactor operated in accordance with the US Pharmacopeia, in order to determine the fine particle fraction (FPF_{imp}, particles < 4.7 µm aerodynamic diameter) leaving the CHC. Fine particle dose ($FPD_{vent/imp}$) was then calculated as the product of TD_{vent} and FPF_{imp} divided by 100. Measurements of TD_{imp} and FPD_{imp} for the pMDI without CHC (n=5 canisters) were also undertaken by impactor to determine baseline drug availability for this formulation.
Results: TED_{vent} (mean ± SD) with the AeroVent™-II CHCs in the dry ventilator circuit was 54.0 ± 6.6 µg/dose, decreasing to 30.5 ± 4.0 µg when the circuit was humidified. FPF_{imp} was 89.5 ± 1.3%. The absence of the ETT for the impactor measurements is deemed unlikely to have had a significant effect on this parameter, since the coarse ballistic component of the aerosol had already been removed by the CHC. Fine particle dose ($FPD_{vent/imp}$) ex AeroVent™-II CHCs was therefore estimated to be close to 48 µg (dry) and 27 µg (humidified). By comparison, TED_{imp} and FPD_{imp} from the pMDI alone were 79.1 ± 1.3 µg and 43.6 ± 1.7 µg respectively.
Conclusions: Under dry conditions, fine particle dose from the new AeroVent™-II CHCs was comparable with that available from the pMDI alone. As expected, the presence of a saturated environment in the humidified circuit reduced the delivery of medication. Nevertheless, fine particle dose was still almost 62% of that available from the pMDI alone under ideal conditions (direct delivery ex actuator under dry conditions).

OF-01-185

PERFORMANCE OF HEATED HUMIDIFIERS AT PEDIATRIC VENTILATORY SETTINGS

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Infant ventilators usually maintain a continuous flow. This improves trigger performance dramatically, however some ventilators use a very low continuous flow. It takes a long time for inspiratory gas to travel from the humidifier chamber to the patient's airway. It may therefore be difficult to consistently maintain the humidity (H) and temperature (T) of delivered inspiratory gas with a heated humidifier (HH). At pediatric ventilatory settings with a low continuous flow, we compared the performances of different HHs. **Methods:** Using a pediatric model lung, we compared the performances of commercially available HHs -MR730 with MR 290, Fisher & Paykel (F&P); Conchatherm IV, Hudson RCI (C IV); and Hummax II, Metran (H II). A sensor to monitor T and H (Moiscope, Mera) was placed between the Y-piece and inspiratory limb of the ventilator circuit. A Servo 300 ventilator was connected to the pediatric model lung (test lung CPL, Dräger) via a pediatric ventilator circuit. Ventilator settings were: peak inspiratory pressure 20cmH_2O; PEEP 5cmH_2O; respiratory rate 30 breaths/min; continuous flow 0.5lpm. Each HH was set to maintain the airway-opening temperature at 32°C and 37°C. **Results:** The table shows T, relative H (RH), and absolute H (AH) at the airway opening. F&P and C IV failed to achieve the set T, although they maintained 100% RH. In H II, T was unstable although it maintained mean T close to the set T.

	32°C			37°C		
	T	RH	AH	T	RH	AH
H II	31.6±1.9 (29.6-34.7)	91.8±0.4 (91.0-92.2)	30.5±3.0	36.7±1.7 (34.7-39.1)	100±0	43.3±3.7
F&P	30.1±0.0 (30.1)	100±0	30.6±0.0	33.9±0.1 (33.6-34.2)	100±0	37.4±0.2
C IV	25.4±0.0 (25.4)	100±0	23.6±0.0	26.8±0.0 (26.8)	100±0	25.5±0.0

Data shown are mean ± SD. Numbers in parenthesis indicate range. **Conclusions:** The HHs reported here failed to maintain the airway-opening T at the set point or T varied greatly under pediatric ventilatory settings with a low continuous flow.

OF-01-188

The Clinical Efficacy of Using the AeroEclipse® Breath Actuated Nebulizer (BAN) in Pulmonary Lab Testing and Implications for General Use.

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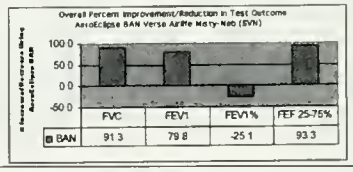
Purpose: To compare the clinical efficacy and delivery time of nebulization of beta agonist bronchodilator with the use of the AeroEclipse® Breath Actuated Nebulizer (BAN) (Monaghan Medical Corp.) as compared to the Airlife Misty-Neb Nebulizer (SVN) (Allegiance Healthcare Corporation).

Methods: Adult patients (n=40) presenting with Asthma (50%), COPD (10%) and other pulmonary disorders (40%); receiving pre and post bronchodilator spirometry testing in our Pulmonary Function Lab were included in the study. Each patient received both nebulizers on two separate visits (less than 24 hours apart). Patient received a nebulizer treatment with the BAN (n=40) 2.5mg Albuterol (0.5ml) in 0.5cc saline run to sputter, or the SVN (n=40) 2.5mg Albuterol in 2.5cc saline (3ml unit dose) run to sputter. FVC, FEV1, FEV1% ratio and FEF 25-75% spirometry was conducted using the Medical Graphics 1085DX pre and 5 minutes post treatment with the BAN and 10 minutes post treatment with the SVN.

Results: The results demonstrated that FVC, FEV1 and FEF 25-75% for patients using the BAN were substantially higher while FEV1% ratio favored the SVN (Table and Chart). Importantly, total nebulization time was reduced from 22 minutes (SVN) to 7 minutes (BAN), and total test time was reduced from 30 minutes (SVN) to 15 minutes (BAN).

Conclusion: The administration of 2.5mg of albuterol with the BAN produced improved results in FVC, FEV1 and FEF 25-75%. Substantially shorter test times delivered by the BAN would allow for more tests and associated revenue. These data support the thesis that the BAN can reduce costs of care by delivering clinically acceptable outcomes in significantly less time.

SPIROMETRY RESULTS				
Absolute % Change by Device			% Difference BAN	
	SVN	BAN		BAN
FVC	5.3	10.2	FVC	91.3
FEV1	7.3	13.1	FEV1	79.8
FEV1%-ratio	1.0	2.1	FEV1%	-25.1
FEF 25-75%	29.8	57.7	FEF 25-75%	93.3



OF-01-206

Addition Of Humidifier To Avoid "Dry Sample Gas" Alarm While Administering NO Via Nasal Cannula With The INOvent.

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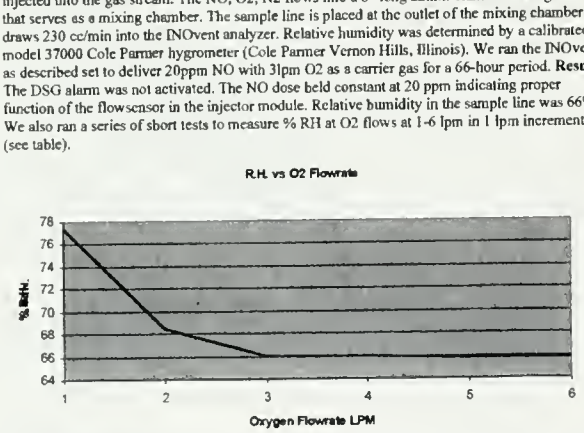
Background: The Datex Ohmeda INOvent (Datex/Ohmeda Madison WI) is used to deliver inhaled nitric oxide (INO) to mechanically ventilated patients as well as spontaneously breathing patients. The INOvent was designed to sample humidified gas from a ventilator circuit. When using the nasal cannula as described in the INOvent manual, dry gas is drawn through the sample line (0% RH). After a period of time this causes a low priority alarm "dry sample gas" (DSG) with both visual and audible indicators. In addition to the alarm, dry sample gas has the effect of shortening the lifespan of the nitric oxide and nitrogen dioxide fuel cells. By placing a bubble humidifier in the gas stream that blows through the injector module the alarm can be prevented. The injector module uses hot-film technology to accurately determine flow of gas in a vent circuit, nasal cannula etc. Inaccurate flow measurement will in turn cause inaccurate NO dosing. Therefore any condensation caused by the humidifier would be of concern. Our study examined the ability of the humidifier to prevent the DSG alarm as well as avoiding condensation in the injector module. **Methods:** 100% oxygen was passed through a standard flowmeter into an AquaPak bubble humidifier (Hudson RCI, Temecula CA). The humidified gas was introduced to the injector module of the INOvent via standard oxygen tubing where NO is injected into the gas stream. The NO, O2, N2 flows into a 6" long 22mm diameter corrugated tube that serves as a mixing chamber. The sample line is placed at the outlet of the mixing chamber and draws 230 cc/min into the INOvent analyzer. Relative humidity was determined by a calibrated model 37000 Cole Parmer hygrometer (Cole Parmer Vernon Hills, Illinois). We ran the INOvent as described set to deliver 20ppm NO with 3lpm O2 as a carrier gas for a 66-hour period. **Results:** The DSG alarm was not activated. The NO dose held constant at 20 ppm indicating proper function of the flowsensor in the injector module. Relative humidity in the sample line was 66%. We also ran a series of short tests to measure % RH at O2 flows at 1-6 lpm in 1 lpm increments (see table).



Conclusion: At the tested NO dosage and O2 flowrate, the humidity was maintained high enough to prevent the DSG alarm but dry enough not to cause condensation in the injector module. Within the parameters of our study, addition of a bubble humidifier can safely avoid the "dry sample gas" alarm on the INOvent when administering INO through a nasal cannula.

OF-01-219

SECOND HAND (S)-ALBUTEROL: RT EXPOSURE RISK FOLLOWING RACEMIC ALBUTEROL.

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Racemic albuterol (RAC), a 50:50 mix of (R)-albuterol[R] and (S)-albuterol [S], is commonly used by RTs. R confers all of the bronchodilatory effects, while S demonstrates proinflammatory properties in *in vitro* and *in vivo* models. S is metabolized 10-fold more slowly, resulting in higher plasma levels that remain in circulation much longer after RAC administration. RTs have a higher rate of developing asthma after entering their profession (7.4 vs 2.4%, respectively; Christiani, 1993). Whether exposure to nebulized medications such as RAC contribute to this, or some other occupational hazard is responsible, is unknown. This study was designed to determine if S and R are detectable in the plasma of RTs. Eligible subjects (at least 18 years old; no asthma or other lung disease; at least 4 hrs of RAC exposure on each of 4 study days) began the study after a 2-day work holiday. Blood was drawn for S and R levels at baseline, 2, 4, and 8 hrs after exposure on Days 1 and 4. Subjects (n=12; mean age 38 yrs) nebulized deliveredwere exposed to approximately 31 mg of RAC by nebulization or MDI (range 22-43 mg) for 4.3 hours (range 3.2-5.5 hours) each day. At baseline on Day 1, On Day 1,mean levels of R and S were below the limit of quantification (BLQ, <2 pg/mL) at baseline, but were detectable after 2 hrs and increased over the 8-hr period. S levels were 1.6-2.5-fold higher than R (Table). On Day 4, approximately 2416 hrs after the last exposure, baseline levels of S, but not R, were detectable (3.7 pg/mL). Peak flow improved or remained unchanged in most subjects, but decreased in 3/12 subjects by an average of 30 mL. R- and S-albuterol are detectable in RTs following administration of RAC. S achieves higher plasma levels that remain in the systemic circulation for a longer period of time.

	Mean R-albuterol Level (pg/mL)	Mean S-albuterol Level (pg/mL)	S:R ratio
Day 1			
Baseline	BLQ	BLQ	NA
2 hours	6.6 (1.2)	9.8 (1.5)	1.6 (0.2)
4 hours	9.6 (3.1)	13.8 (3.1)	1.8 (0.2)
8 hours	10.0 (1.2)	19.6 (3.7)	2.1 (0.1)
Day 4			
Baseline	BLQ	3.7 (0.8)	2.1 (1.1)
2 hours	5.4 (0.5)	11.2 (0.7)	2.2 (0.1)
4 hours	5.8 (0.8)	13.6 (1.6)	2.4 (0.1)
8 hours	8.6 (1.2)	19.9 (2.4)	2.5 (0.2)

OF-01-229

DOES USE OF A NEBULIZER RESULT IN AN INCREASE IN DRUG CONCENTRATION?

James B. Fink, MS, FAARC, Mary Simon, MS, Paul Uster, PhD.
Aerogen, Inc, Sunnyvale, CA

Increasing drug concentrations during the process of nebulization has been identified with use of ultrasonic nebulizers, but has not been well defined with other types of nebulizers. We measured the concentration of drug remaining in each of 5 pneumatic nebulizers (Pari LC Plus, Monaghan AeroEclipse, DeVilbiss Model 800, Allegiance Airlife Misty Neb and Salter 8900) and a novel nebulizer (Aerogen's Aeroneb™ Portable Nebulizer System) after aerosol generation was complete. Each nebulizer was filled with 2.5 mg (3 ml of 0.083%) albuterol sulfate. Upon completion of aerosol flow, the residual drug volume was determined gravimetrically, while residual mass (mg) and concentration (percent of initial concentration) were determined using an HPLC method. Significant differences ($p<0.05$) were determined by ANOVA.

Results:

Device	Residual Volume (mL)	Residual Volume (%)	Residual Mass (mg)	Concentration Change (%)
Pari LC Plus w ProNeb Turbo	1.4	46	1.3	+11.2
Monaghan AeroEclipse w 50 psi	1.1	36	1.3	+37.4
DeVilbiss 800 with Compressor	2.1	70	1.8	+4.8
Airlife Misty Neb w 50 psi	1.0	33	1.2	+37.0
Salter 8900 w 50 psi	1.7	57	1.7	+14.7
Aerogen Aeroneb Nebulizer*	0.4	13	0.3	-2.0

*Residual volume, % of residual volume, residual mass, and change in concentration all are statistically significantly lower with the Aeroneb Portable Nebulizer System, compared with use of any of the other nebulizers.

Discussion: All of the pneumatic nebulizers increased concentration of residual albuterol. Increased residual concentration was inversely related to the residual volume. In contrast, the Aeroneb Portable Nebulizer System did not increase residual concentration, despite a lower residual volume and mass than those resulting from the use of the pneumatic nebulizers.

Conclusion: Concentration of residual medication increases during operation of pneumatic nebulizers, but not with the Aeroneb Portable Nebulizer System.

OF-01-263

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THE DELIVERY TIME, EFFICACY, AND SAFETY OF BETA AGONIST BRONCHODILATOR ADMINISTRATION WITH AN MDI AND VALVED HOLDING CHAMBER VS A CONVENTIONAL T-TYPE NEBULIZER.

Robert S. Pikarsky*, Tracey Farrell, Russ Acevedo, Wendy Fascia and Charles Roman. [1]Respiratory Care, Crouse Hospital, Syracuse, New York.

Purpose: Aerosol delivery consumes the highest level of Respiratory Care resources. This study evaluated the delivery time, efficacy, and safety of albuterol administration with the use of a pMDI with a valved holding chamber (VHC) and a standard small volume nebulizer (SVN).

Methods: A consecutive, non-randomized, mostly COPD population receiving pre & post bronchodilator testing in our Pulmonary Function Lab were studied. Two puffs of albuterol were administered by pMDI with AeroChamber VHC (Monaghan Medical Corp. Plattsburgh, N.Y.). Treatments with the Airlife Misty-Neb Nebulizer SVN (Allegiance Healthcare Corporation) consisted of nebulizing 2.5 mg of albuterol diluted with 3 ml of Normal Saline Unit Dose (UD) using an oxygen flow rate of 8 L/min. The Sensormedics Vmax 22 Pulmonary Function System was utilized to measure FEV1. A standardized subjective questionnaire to determine side effects was completed.

Results: The table shows the albuterol dosages, mean % change of FEV1 from pre-treatment and 10 minute post treatment, mean administration time and tremulousness. The mean treatment time with the pMDI was 2.86 minutes as compared to 8.33 minutes with the SVN ($p<.001$)*. The changes in FEV1 were not significant. There was no difference in heart rate, respiratory rate or nausea.

Conclusion: In this patient population of mostly stable COPD patients 2 puffs of albuterol from an pMDI with a valved holding chamber was equally as efficacious as the SVN with unit dose. The pMDI with VHC offered the best delivery time, efficacy and safety profile between the two aerosol delivery devices.

Clinical Implications: In a health care facility that delivers large volumes of aerosol treatments, the decrease in delivery time realized by the pMDI/VHC delivery method could have a significant impact on resource utilization. Further studies evaluating additional medication dosing regimens measuring safety, efficacy and resource utilization are needed.

Nebulizer (n)	Dose	% Change FEV1	Time (min)	Tremulousness
MDI (21)	180µg - 2 puffs	8.5%	2.86*	1
Misty-Neb (52)	2,500µg UD	9.1%	8.33	2

OF-01-269

THE DELIVERY TIME, EFFICACY, AND SAFETY OF BETA AGONIST BRONCHODILATOR ADMINISTRATION WITH THE AEROECLIPSE BREATH ACTUATED NEBULIZER VS A CONVENTIONAL T-TYPE SMALL VOLUME NEBULIZER.

Robert S. Pikarsky*, Tracey Farrell, Russ Acevedo, Wendy Fascia and Charles Roman. [1]Respiratory Care, Crouse Hospital, Syracuse, New York.

Purpose: Aerosol delivery consumes the highest level of Respiratory Care resources. This study evaluated the delivery time, efficacy, and safety of rapidly nebulized albuterol with the use of a novel breath actuated nebulizer compared to a standard small volume nebulizer. **Methods:** A consecutive, non-randomized, mostly COPD population receiving pre & post bronchodilator testing in our Pulmonary Function Lab were studied. 0.5 ml Albuterol (2.5 mg) with 0.5 ml Normal Saline (NS) was administered with the AeroEclipse Breath Actuated Nebulizer (BAN) (Monaghan Medical Corp. Plattsburgh, N.Y.) using an oxygen flow rate of 8 L/min. Treatments with the Airlife Misty-Neb small volume nebulizer (SVN) (Allegiance Healthcare Corporation) consisted of nebulizing 2.5 mg of albuterol diluted with 3 ml of Normal Saline Unit Dose (UD) using an oxygen flow rate of 8 L/min. The Sensormedics Vmax 22 Pulmonary Function System was utilized to measure FEV1. A standardized subjective questionnaire to determine side effects was completed.

Results: The table shows the albuterol dosages, mean % change of FEV1 from pre-treatment and 10 minute post treatment, mean administration time and tremulousness. The mean treatment time with all BAN patients was 2.67 minutes as compared to 8.33 minutes with the SVN ($p<.001$)*. The changes in FEV1 were not significant. There was no difference in heart rate, respiratory rate or nausea.

Conclusion: The rapid administration of Albuterol in the 0.5 ml + 0.5 ml NS dose using the BAN was equally efficacious as the SVN UD. Delivering 0.5 ml Albuterol (2.5 mg) with 0.5 ml Normal Saline using the BAN offered the best delivery time, efficacy and safety profile between the two devices.

Clinical Implications: In a health care facility that delivers large volumes of aerosol treatments, the decrease in delivery time achieved with the BAN could have a significant impact on resource utilization. The results supported changes in the Respiratory Care practice throughout Crouse Hospital. Further studies evaluating additional medication dosing regimens measuring safety, efficacy and resource utilization are needed.

Nebulizer (n)	Dose	% Change FEV1	Time (min)	Tremulousness
AeroEclipse (12)	2.5µg (0.5 ml albuterol + 0.5 ml NS)	8.2%	2.67*	0
Misty-Neb (52)	2.5µg (3 ml unit dose)	9.1%	8.33	2

OF-01-270

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Venovenous ECMO for Respiratory support in patients with Hemodynamic Instability

Douglas R. Hansell BS, RRT , William P.Murphy BS, Thomas Pranikoff MD, Robert W. Letton MD, Michael H. Hines MD FACS

INTRODUCTION: While the overall use of Venovenous extracorporeal support (VV ECMO) has increased in the treatment of respiratory failure, many centers continue to use venoarterial support. Patients who require inotropic or vasopressor support prior to the initiation of ECMO are sometimes placed on VA ECMO rather than VV because of concerns that there is associated circulatory failure. We examined the use of VV and VA ECMO in our last consecutive 75 patients placed on ECMO for respiratory failure to look for predictors of failure of VV support requiring conversion to VA support. METHODS: We examined the data from the last 75 patients placed on ECMO for respiratory failure at our institution including adults, pediatric patients, neonates and diaphragmatic hernia patients. RESULTS: There were 76 ECMO runs in the 75 patients. All patients were on inotropes or vasopressors at the time of cannulation. Hypotension ranged from mild to severe. All patients were placed on VV ECMO whenever possible, including 21 of 22 adults, 32 of 34 neonates, all 9 CDH patients (one with two VV ECMO runs) and 8 of the 10 pediatric patients. The adult placed on VA support had suffered cardiac arrest from respiratory failure, and was converted to VV ECMO once stable. Two neonates were placed on VA ECMO, one because of size of the jugular vein, and the second because of the presence of pneumopericardium. The two pediatric patients were placed on VA because of cardiac arrest from respiratory failure, and a pulmonary abscess with a pulmonary venous fistula and right and left atrial air. No patients were placed on VA solely because of the presence of vasopressor agents. Of the 71 VV ECMO runs, only one patient was converted to VA ECMO. This was in an infant placed on VV ECMO for post-operative ARDS, who subsequently developed Staphylococcus sepsis and toxic shock syndrome and was converted to VA ECMO 5 days later for a change in her status and the need for hemodynamic support. CONCLUSION: While depressed myocardial function is commonly seen in the face of severe hypoxemia, in patients with a structurally normal heart, hemodynamics can quickly improve once oxygenation is restored and excessive ventilatory pressures are reduced. Therefore the need for inotropic and vasopressor support prior to placement on ECMO for respiratory failure is neither a contraindication for VV support, nor an indication for VA support in patients with structurally normal hearts. OF-01-014

Elective use of ECMO for Complex Tracheal Reconstruction

Douglas R. Hansell BS, RRT, William F. McGurrt Jr. MD, Michael H. Hines MD FACS

INTRODUCTION: Congenital tracheal stenosis, though rare, presents unique challenges to the surgeon because of the perioperative airway management, complexity of the repair and the size of the infant. Previous complications have included breakdown and leakage from the tracheal suture line, as well as the added difficulty of performing the repair around an endotracheal tube. We describe our technique in four patients used to address complex tracheal repairs with elective ECMO support ("ElECMO") for the procedure as well as for post-operative healing. METHODS: We have used ECMO support for the repair of complex tracheal lesions in 4 newborns with long segment tracheal stenosis and complete tracheal rings, diagnosed with rigid bronchoscopy and CT scans, ranging in weight from 2.2-4.3kg. One patient also had complete agenesis of the left lung, and a second child was a quadruplet with double outlet right ventricle and pulmonic stenosis. All four patients had had difficult airway management requiring either heavy sedation or paralysis. All patients underwent similar procedures with exposure through a median sternotomy with mobilization of the great vessels and trachea including a suprahyoid release in three of the four. The patients underwent placement on VA ECMO using a right internal jugular double lumen cannula for venous return and an ascending aortic cannula for arterial inflow after appropriate systemic heparinization and initiation of antifibrinolytics. The trachea was divided obliquely and the endotracheal tube withdrawn out of the field of the repair. Ventilation was ceased. The incisions were extended up and down along opposite sides longitudinally essentially spatulating both ends. The two sides of the trachea were then brought together and sewn in "side to side" fashion with a continuous absorbable suture creating a "sliding tracheoplasty". Prior to completing the suture line the endotracheal tube was advanced under direct vision to stent the repair, and the suture line completed. The repair was covered with a pericardial flap. The patient was converted to VV ECMO using the double lumen IJ cannula, and the arterial cannula removed. The heparin was partially reversed and the mediastinum drained and the sternum closed. The patients were transported to the pediatric intensive care unit on VV ECMO, with ventilator settings utilizing very low tidal volumes and rates to minimize trauma to the newly reconstructed airway. After several days of "airway rest" and appropriate diuresis, the lungs were gently re-expanded and the patient taken off "ElECMO" at 4, 5, 8 and 9 days. All patients were then taken electively to the operating room for rigid bronchoscopy to evaluate the airway. RESULTS: All patients had patent airways with excellent healing of the tracheal suture line with minimal to no granulation tissue. None of the patients had problems with post-operative bleeding despite having their sternums closed while still anticoagulated on ECMO. The patients were subsequently weaned toward extubation. Three of the patients survived although one child required eventual tracheostomy for congenital laryngeal anomalies, and a second child required a later run of ECMO for ARDS and toxic shock syndrome. The fourth child with the congenital heart disease died one month later with hepatorenal failure. CONCLUSION: VA and VV ECMO support provide an excellent environment for complex tracheal reconstruction in newborns, as well as allowing time for tracheal healing by minimizing the use of, and therefore trauma to, the fragile airway. OF-01-015

VALIDATION OF A PISTON-DRIVEN VENTILATOR FOR THE ADMINISTRATION OF HELIOX THERAPY.

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Hartford Hospital, Hartford, CT.

Background: In 1990 Gluck et. al. showed that 60:40 heliox significantly reduced airway pressures and carbon dioxide retention in severe asthmatics who had been intubated for respiratory failure. However, the gas has also been shown to affect the accuracy of volumes delivered by certain mechanical ventilators. To our knowledge there are few mechanical ventilators approved by the FDA for the administration of heliox therapy. We conducted a bench validation of Mallinckrodt Nellcor Puritan Bennett's 760 ventilator because of its piston driven design. We hypothesized that this piston-driven design would avoid the technical problems that are associated with heliox and the computer controlled valves in other modern ventilators. We also compensated for the important density difference between heliox and standard oxygen therapy by utilizing the CosmoPlus (Novametrix Medical Systems) external-monitoring device.
Methods: The bench validation was conducted using a 70:30 heliox mixture with MNPB's 760 ventilator, the CosmoPlus monitoring device and the TTL test lung (Michigan Instruments). The 760 was set to maintain a rate of 10 bpm and an inspiratory time of 0.9 sec. The test lung was adjusted to a "normal" model (compliance of 70 mL/cmH_2O and a resistance of 5 cmH_2O/L/sec) and an "asthmatic" model (compliance of 30 mL/cmH_2O and a resistance of 50 cmH_2O/L/sec). The CosmoPlus was positioned between the wye and the test lung in order to record the most accurate pressure and volume measurements. A set of 50 data points was collected during each interval of both the pressure control (Pi = 10-40 cmH_2O) and volume control (Vt= 200-1200 mL) modes of the 760. Tidal volumes and distending pressures during both heliox and oxygen ventilation were compared for validation. Per operators manual, the volume control validation was allowed a difference of ± 10 mL + 10% of setting, while the pressure control validation was allowed a difference of ± 3 cmH_2O + 2.5% of setting. The use of PEEP at 15 cmH_2O was also validated in the "asthmatic" model.
Experience: Using the CosmoPlus external monitoring device and the TTL test lung we were able to show that this ventilator is capable of delivering a 70:30 heliox mixture as accurately as pure oxygen during both volume control and pressure control ventilation. Using the Student's T-test for a difference in two means, we determined that the 760 exhibited no significant difference in accuracy between heliox and oxygen delivery (p=.05) in the "normal" and "asthmatic" model. Upon further examination of the data we discovered some potential clinical benefits to the use of heliox therapy. Comparing the mean tidal volumes of heliox and oxygen delivered by the ventilator at identical distending pressures, we found that the heliox tidal volumes were significantly greater than the oxygen tidal volumes.
Conclusion: After conducting our validation of MNPB's 760, we are confident that while used in conjunction with the Novametrix CosmoPlus external monitoring device, this piston-driven ventilator is both safe and effective for use in the delivery of heliox therapy. We also found evidence that heliox therapy potentially presents a new lung protective strategy whereby respiratory care providers can maximize delivered volumes while maintaining minimal distending pressures. Further research involving human lung models is necessary to further validate the MNPB 760 with heliox. OF-01-019

CLINICAL MANAGEMENT OF ACUTE LUNG INJURY (ALI) PATIENTS WITH THE NIH ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS) NETWORK'S LOW TIDAL VOLUME (V_T) VENTILATION PROTOCOL.

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Background: The NIH ARDS Network trial compared traditional V_T ventilation at 12 mL/kg to 6 mL/kg and demonstrated a significant mortality reduction (39.8 vs. 31% respectively) in ALI/ARDS patients. SFGH has commenced voluntary utilization of the NIH ARDS Network protocol to manage ALI/ARDS patients. We inquired how closely the study target goals for lung protective ventilation could be maintained during clinical practice. **Methods**: We gathered data on all 36 ALI/ARDS patients managed with the NIH ARDS Network protocol between September 2000 and June 2001. Ventilator parameters including V_T in mL/kg PBW, end-inspiratory plateau pressure (P_{PLAT}), positive end-expiratory pressure (PEEP), fractional oxygen concentration (F_IO_2), respiratory rate (f), arterial oxygen tension (PaO_2), arterial carbon dioxide tension ($PaCO_2$) and arterial pH were extracted from 2 reference ventilator checks on days 1,3,7 and 14 of protocol management. Data were analyzed using Kruskal-Wallis tests and Dunn's Multiple Comparisons tests. The incidence of data being within target range was analyzed using 2-sided Fisher's Exact tests. Alpha was set at 0.05. **Results**: Lung protective ventilation goals were maintained during the first 3 days of protocol management, although, the percentage of data meeting ARDS Network target specifications fell below the levels achieved during the clinical trial. The ability to achieve protocol management goals deteriorated by the second week of management.

Variable	Day 1	Day 3	Day 7	Day 14
V_T (mL/kg)	6.02 ± 0.96	6.18 ± 1.18	6.98 ± 1.49†	7.75 ± 2.11†
P_{PLAT} (cm H_2O)	27.4 ± 5.8	28.7 ± 9.6	25.8 ± 6.8	29.2 ± 11.8
PEEP (cm H_2O)	10.0 ± 3.2	10.0 ± 4.0	8.3 ± 3.9	7.5 ± 3.0†
F_IO_2	0.60 ± 0.18	0.58 ± 0.19	0.48 ± 0.14	0.45 ± 0.16
pH	7.36 ± 0.08	7.37 ± 0.08	7.39 ± 0.05	7.37 ± 0.05
$PaCO_2$ mm Hg	41.3 ± 7.9	45.2 ± 7.1†	47.2 ± 9.3†	46 ± 6.9
PaO2 mm Hg	83.2 ± 31.6	78.6 ± 20.3	82.7 ± 20.3	111.6±30.4†
Percentage of variables that met ARDS Net "On-Target" Criteria				
V_T	78%	71%	37%†	43%†
P_{PLAT}	69%	63%	68%	50%†
V_T/P_{PLAT}	63%	58%	26%†	14%†
PEEP/F_IO_2	90%	75%†	74%†	84%
f/pH	91%	91%	83%	88%

† $p < 0.05$ compared to Day 1 data
Conclusion: The NIH ARDS Network lung protective ventilation protocol can be successfully adapted to clinical practice. However, the ability to sustain the target ranges achieved by the study appear more difficult to maintain over an extended period of mechanical ventilation during clinical practice. OF-01-134

ASSESSMENT OF EXPIRATORY VALVE RESISTANCE IN ADULT VENTILATORS. Jack Walsh RRT,[1] Richard Branson BA RRT FAARC,[1] Robert Kacmarek PhD RRT FAARC,[1,2] Dean Hess PhD RRT FAARC.[1,2] [1]Massachusetts General Hospital, [2]Harvard Medical School, [3]University of Cincinnati.

In the past, the exhalation valve of mechanical ventilators has been implicated as an important contributor to expiratory resistance. We conducted this study to assess the role of the exhalation valve in 7 newer generation adult mechanical ventilators. **Method:** The following ventilators were assessed - Drager Evita 4, Hamilton Galileo, Pulmonetic LTV-100, Puritan-Bennett 7200, Puritan-Bennett 840, Servo 300, and Thermo Tbird. A standard adult circuit was used. The ventilator was attached to the single bellows of a Michigan Instruments TTL set at a compliance of 20 ml /cm H_2O and one of two resistances (5 and 20 cm H_2O/L/s). The ventilators were set to a tidal volume of 0.4 or 0.8 L, and PEEP of 0, 5, 10 and 20 cm H_2O. An end-inspiratory pause of 1 s was set on the ventilator. Expiratory flow curves were assessed with and without the exhalation valve. To assess the effect of no exhalation valve, the expiratory limb tubing was disconnected from the exhalation valve during the end-inspiratory pause. Pressure, flow, and volume were measured at the ventilator Y-piece using a Novametrix CO_2SMO and recorded to a computer for later analysis. Peak expiratory flow and SF50 were determined as previously described (Intensive Care Med 1999; 25:799); SF50 = arctg ($\dot{V}_{50}/V_{T50}$) where $\dot{V}_{50}$ is the flow at 50% of the exhaled tidal volume and V_{T50} is 50% of the exhaled tidal volume. The SF50 represents the angle of the slope of the flow-volume curve during the last 50% of the exhaled tidal volume. **Results:**

	SF50 (degrees)			Peak Expiratory Flow (L/s)		
	No Valve	Valve Present	P-value	No Valve	Valve Present	P-value
Evita 4	69.7 ± 7.0	66.2 ± 7.1	0.171	1.1 ± 0.4	0.9 ± 0.3	0.125
Galileo	76.0 ± 5.3	73.3 ± 5.2	0.152	1.7 ± 0.6	1.3 ± 0.4	0.061
LTV-1000	76.6 ± 4.8	72.9 ± 4.6	0.035	1.7 ± 0.6	1.3 ± 0.4	0.009
PB7200	70.9 ± 7.9	60.9 ± 5.5	0.001	1.1 ± 0.4	0.6 ± 0.2	0.001
PB 840	70.7 ± 8.1	63.9 ± 7.8	0.021	1.2 ± 0.4	0.9 ± 0.3	0.032
Servo 300	68.2 ± 7.9	62.9 ± 6.9	0.054	1.1 ± 0.4	0.8 ± 0.2	0.025
TBird	76.5 ± 5.7	73.2 ± 5.4	0.105	1.9 ± 0.7	1.4 ± 0.5	0.016

There were no significant effects of PEEP level on SF50 or peak expiratory flow (P>0.05 in all cases). **Conclusions:** For these ventilators, there was an increase (mean 37%) in peak expiratory flow when the exhalation valve was removed. However, the increase in SF50 due to the exhalation valve was modest (mean increase 7.5% for the ventilators evaluated). Consistent with the results of others (Intensive Care Med 1999; 25:799), this suggests that the second 50% of exhalation may be relatively unaffected by the exhalation valve and might, therefore, be useful to estimate patients' respiratory mechanics during ventilatory support. However, the initial expiratory flow may be less useful in this regard because it is affected to a greater extent by the resistance through the endotracheal tube. Our data suggests that exhalation valves in current generation ventilators may contribute less to expiratory resistance than in the past.

OF-01-143

Optimizing MAP in HFOV by Maximizing Amplitude

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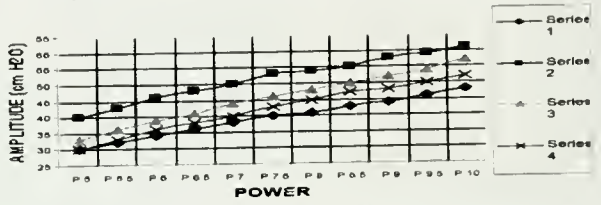
Introduction: The purpose of this work is to establish an objective method to optimize mean airway pressure (MAP) during HFOV. Current practice involves setting MAP 2-8 cm H2O higher than the MAP on conventional ventilation, in order to optimize oxygenation. However, little attention is directed towards amplitude, sub-tidal volume and ventilation. We sought to determine whether setting MAP at different points on the static pressure-volume curve resulted in changes in amplitude, potentially providing the opportunity to optimize ventilation. We hypothesized that optimal MAP is achieved at the midpoint between the lower inflection point (LIP) and upper inflection point (UIP) of a static pressure-volume (P-V) tracing and is confirmed by maximal amplitude (delta P). **Methods**: A static P-V tracing was obtained using a balloon model that was submerged and stabilized in a 50-gallon tank. The LIP and UIP were identified and used as markers for data collection. HFOV was initiated through a #8.0 ETT at the following settings: Hz 4, I-time % 50, and Bias Flow of 30 L/m. Four MAPs were chosen along the P-V curve as follows: (1) below the LIP, (2) midpoint between LIP and UIP, (3) shoulder of the UIP, and (4) above the UIP. In each experimental condition, MAP was held constant and power changes were made in increments of 0.5 for a range of 5.0 to 10.0. Amplitudes were then documented at each study condition. **Results**: The largest amplitudes were achieved when the MAP setting was positioned at the midpoint between the LIP and UIP. As the MAP was increased and was positioned near the shoulder of the UIP, amplitudes decreased but still remained higher than when the lung model was above the UIP and below the LIP.



Discussion: Our data suggests that at a power of 10, the maximum amplitude is achieved when MAP is set at the steepest slope of the static P-V tracing. These results indicate that position on the static P-V curve can be determined based on the ratio of power to displayed amplitude. Prior studies and management strategy indicate that MAP should be set near the shoulder of the UIP to improve oxygenation by recruiting collapsed alveoli. The findings represented in this study indicate that MAP can be adjusted until amplitude starts to decrease for a given power. As the lung recruits into overdistension a further reduction in amplitude will occur. At this point, MAP should be reduced to increase amplitude to near previous levels. Power should not be increased for a drop in amplitude as this will only increase damage in the condition of overdistension. Given the difficulties often encountered with ventilation during HFOV this data establishes that MAP should be adjusted to optimize position on the static P-V curve.

OF-01-165

EFFECT OF TUBE COMPENSATION (TC) VS PRESSURE SUPPORT (PS) ON CARINAL PRESSURE AND WORK INDICES: A BENCH STUDY

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BACKGROUND: PS provides a constant pressure assist, regardless of patient effort to overcome resistance of an artificial airway while TC provides a variable pressure assist level in direct proportion to patient effort. With the ventilator tested, TC attempts to maintain carinal pressure at set-PEEP. **STUDY QUESTIONS:** 1) What impact does TC have on minimizing carinal pressure changes, and on other indices of inspiratory work compared to PS; and 2) What influence does endotracheal tube size (ETT) have on PS and TC? **METHODS:** Lung model: A computerized lung simulator (ASL-5000, Igmar Medical) was set to a single lung model with C=50 mL/cm H_2O, R=10 cm H_2O/L/s, RR=20, an inspiratory effort of –15 cm H_2O and settings resulting in an I:E of ~1:3.0. Ventilator settings: A PB-840 ventilator (Carlsbad CA) was set to PEEP=0 cm H_2O, FIO_2=0.21, and trigger of –1 cm H_2O. For PS breaths, flow acceleration=50% and expiratory sensitivity=10%. The ventilator was tested at: PS=0, 5, and 10 cm H_2O; and TC=50 and 100%. Airways: ETT of an ID of 6, 7, 8, and 9 mm were studied. The distal end was attached to the lung simulator and the proximal end to the circuit wye with identical adapters. Measurements: The simulator measured flow, volume, and pressure. These measurements were taken immediately distal to the airway tested, therefore airway pressure is considered to reflect 'carinal' pressure. Minimum pressure (P_{min}) after trigger, time to P_{min} after trigger, and work done from the onset of flow to P_{min} were calculated by the lung simulator. Data: Ten breaths of data were analyzed for each data set. Results are mean values; $p<0.005$ (*) was considered significant comparing all levels of support (0.05/10 comparisons=0.005); only p values for PS=0 vs other levels are reported. **RESULTS:**

		PS=0	PS=5	PS=10	TC=50	TC=100
P_{min} (cm H_2O)	ETT=6	-7.34	-6.61*	-5.93*	-6.63*	-6.23*
	ETT=7	-5.79	-5.65	-5.47*	-5.50*	-5.44*
	ETT=8	-5.24	-5.42	-5.17	-5.19	-5.23
	ETT=9	-5.25	-5.17*	-4.96*	-4.94*	-4.93*
Time to P_{min} (msec)	ETT=6	198.2	180.2*	46.6*	186.8	64.6*
	ETT=7	188.8	50.4*	44.0*	49.2*	49.2*
	ETT=8	49.0	46.8	41.2*	46.8	48.6
	ETT=9	49.4	48.4	38.8*	44.6*	44.4*
Work, flow onset to P_{min} (J)	ETT=6	33.86	24.64*	-0.19*	27.45	0.38*
	ETT=7	32.30	0.12*	-.015*	0.07*	0.06*
	ETT=8	0.22	0.03	-0.14*	0.08	0.18
	ETT=9	0.17	0.09*	-0.08*	0.10	0.12

CONCLUSIONS: 1) Under current test conditions, ETT=8 & 9 had minimal effect on the 3 measured parameters; 2) P_{min} was reduced with both TC levels and PS=10 in all airways but ETT=8, 3) P_{min} never exceeded -4.93 cm H_2O (target=0); 4) time to P_{min} was reduced most with PS=10 and TC=100; 5) work from onset of flow to Pmin was reduced in small airways with TC=100 and PS=5 and in all airways by PS=10. PS=10 may have provided excessive work (negative values). The clinical relevance of these findings remains to be determined.

OF-01-172

HELIOX IN ARDS: A PILOT STUDY. David Willms MD, Jodette Brewer RRT, Melissa Brown RRT, Ashlynn LeBlanc RN. Sharp Memorial Hospital, San Diego, California. Sharp Mary Birch Hospital for Women, San Diego, California.

Background: We hypothesized that heliox administered to early ARDS patients would improve gas exchange by improving ventilation of partially atelectatic regions and augmenting diffusive gas mixing. A pilot study was initiated and the results in the first 5 patients reported here. **Methods:** Five ARDS patients intubated < 96 h, and with FiO_2 < .80 were entered after informed consent. Subjects were ventilated with a Servo 300 in PRVC or PCV mode, with V_T 6-8 ml/kg. A Novametrix Co_2smo Plus respiratory mechanics monitor, calibrated to the heliox concentration, was attached at the patient Y and used for V_T, expired CO_2 and V_D/V_T monitoring. Heliox was begun with FiO_2 equal to baseline; reduction in FiO_2 was accomplished if feasible based on oxygenation. ABGs and physiologic measurements were obtained at baseline and at 1, 4, and 8 h of heliox, whereupon subjects were returned to nitrogen-oxygen breathing. Efforts were made to maintain stable V_T, PEEP, and respiratory frequency throughout. One patient required reduction in set rate due to hypocapnea. Four patients were pharmacologically paralyzed at the time of study. **Results**: Baseline characteristics (mean values) were: Age 42 y; FiO_2 0.54; PEEP 11.8 cmH_2O; PaO_2 82 torr; PCO_2 43.8 torr; V_D/V_T 0.74; PaO_2/FiO_2 ratio 156. Mean values for the gas exchange values were not significantly changed during the 8 h study (see Table); however two individual patients experienced a notable reduction in $AaDO_2$ from baseline to 8 h (292 to 171, and 162 to 73). No adverse events from heliox therapy were noted.

	Baseline	1 h	4 h	8 h	p value*
FiO_2	.54	.55	.47	.47	0.26
PCO_2	43.8	43.8	48.8	45.6	0.32
PaO_2/FiO_2	156	130.6	151.3	160.4	0.49
V_D/V_T	0.68	0.69	0.67	0.65	0.27
$AaDO_2$	260	279	222	220	0.23

*Paired Student's t-test, baseline vs. 8 h values

Conclusion: In this short-term heliox trial, no significant change in gas exchange was noted. However 2 patients had a substantial reduction in $AaDO_2$. It is possible that some individual patients may benefit from heliox, or that a longer duration of heliox inhalation may have an effect. Future study is planned.

OF-01-182

INTERACTIONS BETWEEN AUTO-TUBE COMPENSATION (ATC), MODERATE LEVEL PRESSURE SUPPORT (PS), AND PRESSURE-RISE TIME (PRT) ON WORK OF BREATHING (WOB)

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Background ATC augments ventilator inspiratory flow rate $\dot{V}_I$ to achieve the proximal airway pressure target at the distal tip of the endotracheal tube (ETT), thus counterbalancing the imposed WOB of the artificial airway. A moderate level of PS often is used for the same purpose. PRT prolongs the time to achieve the PS level, and may increase WOB. We studied the interactions of ATC and PRT on peak $\dot{V}_I$, V_T and WOB during PS. **Methods** A standard WOB lung model was constructed using a Michigan Instruments TTL set at a compliance of 27 mL/cm H_2O; powered by a Veolar ventilator set to create a V_T demand of 500 mL at a respiratory rate of 24, a peak $\dot{V}_I$ demand of 50 L/m and inspiratory time of 0.8 s. The Drager E-2 treatment ventilator was set at CPAP of 5 cm H_2O with PS of 10 cm H_2O. The PRT was set at 0.25 s; the flow trigger was set at 5 L/m. We measured WOB performed by the drive ventilator to displace the "patient" compartment (WOBc). WOBc approximated total imposed WOB (ETT + circuit). Experiments were done with ATC turned off and at an ATC of 100, 75 and 50% compensation set to the ETT size used in the model (7.0 mm ID). Experiments were done with and without PRT. Measurements were made with a BICORE CP-100 monitor; 10 breaths were used for analysis. Data was reported as mean ± standard deviation and analyzed using repeated-measures analysis of variance and both Dunnett and Tukey-Kramer tests. Alpha was set at 0.05. **Results** Compared to PS alone, adding ATC increased both peak $\dot{V}_I$, and V_T, and reduced WOBc. However, adding PRT increased WOBc at all levels of ATC, but did not appreciably affect peak $\dot{V}_I$ and V_T. Decreasing ATC support caused a small increase in WOBc. Only 5 discreet comparisons were not statistically significant ($p > 0.05$): peak $\dot{V}_I$ (*), WOBc (†, ‡;), and V_T (§,ǁ)

PRT = 0	ATC OFF	ATC 100	ATC 75	ATC 50
WOBc (J/L)	0.38 ± .03‡	0.19 ± .01	0.23 ± .02†	0.25 ± .02†
(L/m)	77 ± 1.0*	109 ± 1.9	96 ± 1.1	102 ± 0.3
V_T (mL)	676 ± 5	766 ± 5§	719 ± 6ǁ	707 ± 5
PRT = 0.25 s	ATC OFF	ATC 100	ATC 75	ATC 50
WOBc (J/L)	0.58 ± .01	0.34 ± .01	0.38 ± .01‡	0.42 ± .02
(L/m)	78 ± 1.0*	114 ± 1.3	101 ± 1.2	92 ± 1.3
V_T (mL)	660 ± 0	769 ± 6§	720 ± 7ǁ	700 ± 0

Conclusion: Our results suggest that ATC enhances the WOB-reducing effects of moderate level PS. Decreasing the % ATC support caused a minor increase in imposed WOB and therefore, ATC should be used at 100% support. PRT counters the effects of ATC and should not be used in conjunction with ATC.

OF-01-199

INTERACTIONS BETWEEN AUTO-TUBE COMPENSATION (ATC) AND VOLUME CONTROL-AUTO FLOW (VC-AF) ON WORK OF BREATHING (WOB) DURING LOW TIDAL VOLUME (V_T) VENTILATION

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Background ATC augments ventilator inspiratory flow rate () to achieve the proximal airway pressure target at the distal tip of the endotracheal tube (ETT), thus counterbalancing the imposed WOB of the artificial airway. VC-AF incorporates a variable, decelerating flow pattern to deliver the target V_T at the lowest airway pressure, and thus, may reduce WOB during patient-triggered breaths. We studied the combined effects of ATC and VC-AF on peak , V_T and WOB during simulated patient-triggered, low V_T ventilation. **Methods** A standard WOB lung model was constructed using a Michigan Instruments TTL set at a compliance of 27 mL/cm H_2O, powered by a Veolar ventilator set to create a V_T demand of 400 mL at a respiratory rate (f) = 24, a peak demand = 39 L/m and inspiratory time (T_I) of 0.8 s. The Dräger E-2 treatment ventilator was set in VC-AF at a target V_T of 400 mL, f = 20, T_I = 0.9 s and flow trigger = 5 L/m. We measured WOB performed by the drive ventilator to displace the "patient" compartment (WOBc). WOBc approximated total imposed WOB (ETT + circuit). Experiments were done with ATC off and at ATC of 100, 75 and 50% compensation set to the ETT sizes used in the model (7.0 and 6 mm ID). Measurements were made with a BICORE CP-100 monitor. After stabilization of V_T delivery, 10 breaths were used for analysis. Data was reported as mean ± standard deviation and analyzed using repeated-measures analysis of variance and both Dunnett or Tukey-Kramer tests. Alpha was set at 0.05. **Results** A V_T-overshoot occurred as V_T demand equaled the pre-set target V_T. Adding ATC increased peak delivery and caused a slightly greater V_T-overshoot. This resulted in a 36-38% reduction in WOBc for ETT sizes of 6 and 7 mm respectively. Only 3 comparisons were not statistically significant (*, †, ‡; $p > 0.05$).

ETT = 7.0 mm	ATC OFF	ATC 100	ATC 75	ATC 50
WOBc (J/L)	0.24 ± .01	0.15 ± .01*	0.16 ± .02*	0.18 ± .01
(L/m)	58 ± 1	71 ± 0.9	66 ± 1	63 ± 0.7
V_T (mL)	470 ± 0	486 ± 5	480 ± 0†	480 ± 0†
ETT = 6.0 mm	ATC OFF	ATC 100	ATC 75	ATC 50
WOBc (J/L)	0.56 ± .01	0.36 ± .01	0.41 ± .01	0.45 ± .01
(L/m)	45 ± 0.4	51 ± 0.6	50 ± 0.6	48 ± 0.6
V_T (mL)	450 ± 0	470 ± 0‡	470 ± 0‡	461 ± 3

Conclusion: Our results suggest that ATC enhances the WOB-reducing effects of VC-AF. Reducing the level of ATC support caused a minor increase in imposed WOB, and therefore, ATC should be used at 100% compensation.

OF-01-200

OPTIMIZING MAP SETTINGS DURING HFOV BY ANALYZING WAVEFORM DIFFERENCES PRE & POST THE ETT

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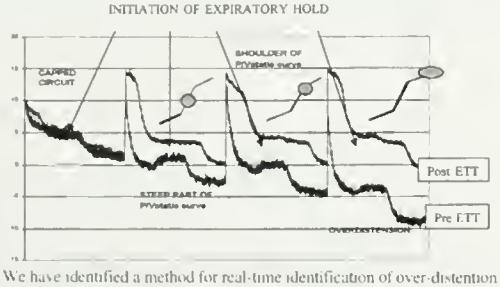
Introduction: Timely adjustments of MAP during HFOV are necessary to limit ventilator induced lung injury (VILI). Current literature and clinical management practice supports the adjustment of MAP to deliver sub-tidal volumes at or just below the upper inflection point of the static pressure/volume curve (P/Vstatic). Current monitoring tools (radiological, pulse-ox and ABG's) provide supportive evidence. We hypothesize that optimal MAP can be set and maintained by interpretation of real-time pressure-time tracings (P/T) captured pre and post ETT.

Methods P/Vstatic curves were generated in a multiple balloon lung model submerged in a fifty-gallon tank at three different depths. A HFOV was then attached to the lung model via a #9 ETT. Analog P/T waveform tracings were collected pre- & post- the patient wye utilizing four study conditions as follows. HFOV circuit capped, MAP set on the linear portion of the P/Vstatic curve, MAP set on the shoulder of the P/Vstatic curve and MAP set at overdistension. The MAP, bias flow, inspiratory time percent (IT%) and frequency were kept constant (MAP=20, bias flow=30, IT%=.50, freq=5 Hz). Power setting was adjusted to maintain the same amplitude at each compliance and data recorded. The signals were then converted to digital at 50,000 data points per second (using a Tektronix TDS 3020). Data was collected and differences graphed and overlaid for each study condition. Our analysis focused on the portion of P/T waveform at actuation of the expiratory hold.

Results: Qualitative differences between pre and post ETT tracings in the model increased with decreasing compliance. Negligible variation was observed with the circuit capped.



Discussion We have identified a method for real-time identification of over-distention in HFOV. Our findings represent an improvement over currently recognized monitoring techniques that are limited by sensitivity or specificity issues. We believe that further investigation is necessary and suggest that it be directed to development of this method and other real-time monitoring options adaptable to the clinical environment.

OF-01-201

PRESSURE/FLOW CHARACTERISTICS OF THE EZPAP POSITIVE AIRWAY PRESSURE THERAPY SYSTEM

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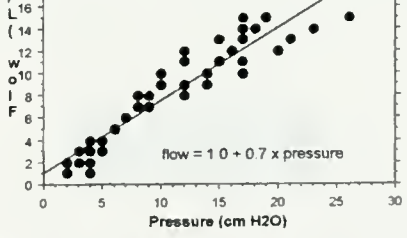
BACKGROUND The EzPAP positive airway pressure therapy system is indicated "for lung expansion therapy and the treatment and prevention of atelectasis". The device generates positive airway pressure using flow input from a standard air or oxygen flowmeter and may be used with a nebulizer. The purpose of this study was to evaluate the pressure/flow characteristics of the EzPAP with and without a nebulizer. **METHODS** The gas inlet port of the EzPAP was connected to an air flowmeter. The pressure monitoring port was attached to a pressure gauge calibrated with a water manometer. We measured the inspiratory and expiratory pressures with 3 normal volunteers inhaling and exhaling normally. Input flows were adjusted in 1 L/min increments from 0 to 15 L/min. The experiment was repeated with a nebulizer attached. The nebulizer was powered by a flowmeter set to 6 and 8 L/min. Each experimental condition was evaluated 3 times. Data were analyzed with linear regression. **RESULTS** The addition of a nebulizer had little effect on the airway pressures generated. The data below show airway pressure as a function of the flow set on the flowmeter for all experiments combined. The coefficient of determination (r^2) was 0.88. The system maintained airway pressure throughout the respiratory cycle with the inspiratory pressure averaging 45% of expiratory. The chart illustrates expiratory data.



EXPERIENCE: The EzPAP was very easy to setup and adjust. Breathing on the device was similar to a PEP device except that inspiratory pressure was elevated. The volunteers commented that they felt a noticeable increase in FRC. With the use of higher pressures/flows, subjects felt they needed to actively exhale.

CONCLUSIONS: The EzPAP delivers reliable and controllable pressures within a clinically useful range for lung expansion therapy. An easily remembered equation allows prediction of the flow necessary to achieve a desired pressure.

OF-01-204

THE RESPONSE OF ADAPTIVE SUPPORT VENTILATION (ASV) TO VARYING SPONTANEOUS MINUTE VENTILATION AT DIFFERENT COMPLIANCE AND RESISTANCE IN A LUNG MODEL. R. Wayne Lawson, MS, RRT, David L. Vines, MHS, RRT, David C. Shelledy, PhD, RRT. The University of Texas Health Science Center at San Antonio, TX. **BACKGROUND:** ASV is a servo-controlled mode of ventilation offered on the Hamilton Galileo, (Hamilton Medical, Reno, Nevada) designed to deliver pressure-targeted tidal volumes at a variable rate, to achieve a target minute volume while utilizing protective lung strategies. The mode will adapt to changing patient demand, from full ventilatory support to total spontaneous breathing, as the patient takes over a greater share of the work of breathing. The purpose of this study was to evaluate the ability of ASV to achieve targeted minute volumes in the face of varying levels of patient spontaneous ventilation, and under different conditions of compliance and resistance, using a two-compartment lung model (Michigan Instruments Inc., Grand Rapids, MI) to simulate spontaneous breathing. **METHODS:** The driver lung, lung B, was ventilated using minute ventilations of 5 L (f = 10 bpm V_T = 500 ml f = 15 bpm V_T = 335 ml f = 30 bpm V_T = 165 ml); 7 L (f = 10 bpm V_T = 700 ml f = 15 bpm V_T = 470 ml f = 30 bpm V_T = 235 ml); 9 L (f = 10 bpm V_T = 900 ml f = 15 bpm V_T = 600 ml f = 30 bpm V_T = 300 ml). The spontaneous lung, lung A, was ventilated using ASV, programed for an ideal body weight of 70 kg. For each experimental condition, measurements were made at a normal compliance (0.05 L/cm H_2O) and resistance (2.7 cm H_2O/L/sec), decreased compliance (0.02 L/cm H_2O), and increased resistance (17.6 cm H_2O/L/sec). Alveolar ventilation was calculated using the following formula (minute ventilation minus respiratory rate times deadspace). An anatomic deadspace of 150 ml was chosen as a normal value for a 70 kg patient. **RESULTS:** Across all conditions combined, there were no significant differences (p>.05) for actual minute volume and calculated alveolar ventilation when driver minute volume was 5 L/m (8.97 ± 2.93 & 6.56 ± 1.83), 7 L/m (8.60 ± 2.62 & 6.45 ± 1.57), or 9 L/m (9.06 ± 2.50 & 6.90 ± 1.75). Under all conditions combined, there were also no significant differences (p>.05) between actual minute volume and calculated alveolar ventilation when compliance and resistance were normal (9.64 ± 3.51 & 7.27 ± 2.27), decreased compliance (8.67 ± 2.74 & 6.12 ± 1.58), or increased resistance (8.31 ± 0.99 & 6.48 ± 0.77). Table 1 displays minute ventilation and calculated alveolar ventilation for each level of spontaneous ventilation, compliance and resistance.

	Normal C/R		↓C		↑Raw	
Drive V_E	V_E Actual	V_A calc	V_E Actual	V_A calc	V_E Actual	V_A calc
5 L/min	9.73 ± 4.74	7.16 ± 3.12	8.87 ± 3.06	6.09 ± 1.61	8.30 ± 1.04	6.42 ± 0.47
7 L/min	9.30 ± 3.81	6.94 ± 2.20	8.50 ± 3.33	6.12 ± 2.01	8.00 ± 0.80	6.29 ± 0.65
9 L/min	9.90 ± 3.47	7.71 ± 2.51	8.63 ± 3.09	6.15 ± 2.04	8.63 ± 1.37	6.84 ± 1.57

CONCLUSION: ASV effectively maintained minute ventilation and alveolar ventilation under varying conditions of spontaneous ventilation, compliance and airway resistance.

OF-01-210

DETERMINING IF THE LOWER INFLECTION POINT ON A PRESSURE VOLUME CURVE CAN BE ACCURATELY ESTIMATED BY USING A SIMPLE VOLUME MANEUVER

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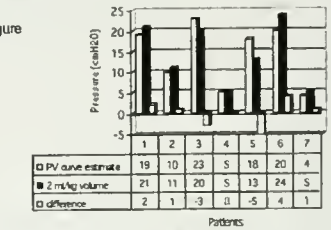
INTRODUCTION: This work investigates the accuracy of a simple volume maneuver to estimate the lower inflection point on a pressure volume curve. Recent literature suggests that the lower inflection point indicates the first significant recruitment of new lung units. However, capturing pressure volume curves in the clinical arena is time-consuming, and requires specialized equipment and skill set. Our experience shows that the lower inflection point corresponds with a reproducible narrow volume range.

METHODS: Static P-V curves were generated for seven patients with P/F ratio <200, average lung injury score of 3.0, and all having risk factors for ARDS. Patients with a history of chronic obstructive pulmonary disease, heart failure, or the presence of an air leak via any thoracostomy tubes were excluded. Static P-V curves were captured using two commercially available ventilators and the valve method described by Estetter, et al (respiratory rate 60, tidal volume 50cc, I: E ratio 1:5, and FIO2 80-100%). Lower Pflex was calculated for each study condition using a fitted logistic curve and commercially available statistical software (STATA). Plateau pressures were measured in each study participant using a two-second inspiratory hold at set volumes of 1, 2, 3 and 4 ml/kg ideal body weight. Plateau pressure measurements were compared with the Pflex estimates from the static pressure volume curve.

RESULTS: The lower inflection points ranged from 4 – 23 cmH2O for the 7 patients. The plateau pressure measured at the 2ml/kg inspiratory volume most closely approximated the lower inflection point as estimated by the statistical software. The adjacent figure arranges the data for each study subject in graphical and tabular format.

Figure



DISCUSSION: Our data suggests that in this patient population PEEP can be estimated by performing a static P/V maneuver at 2 ml/kg ideal body weight. We believe this method may provide a reproducible alternative to Pflex estimation as a method of identifying ideal PEEP. This technique may alleviate the need to generate, record and interpret static pressure volume curves. Additional research is needed to establish the, practicality, reproducibility, safety, and clinical efficacy of the approach.

OF-01-212

DETERMINATION OF OPTIMAL SETTINGS FOR HIGH PRESSURE RECRUITMENT MANEUVERS (RM) IN AN ARDS SHEEP MODEL.

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Animal data and preliminary patient data clearly suggest that the use of lung RM can markedly improve PaO_2 levels. However, controversy regarding the approach and the need to optimize lung RM still exists. Based on data from a previous study[1] which shows greatest recruitment at PIP of 60 in contrast to 40 cm H_2O we compared 3 high pressure RM (PIP of 60 cm H_2O) with 3 different PEEP levels. **Methods:** This study was designed as a Cross-Over Study. Saline lung lavage injury was performed in 8 sheep (30.5±2.1 kg) until PaO_2 decreased to 63±2.5 mm Hg at an F_IO_2 of 1.0 and PEEP of 5 cm H_2O (BL). Each RM consisted of a maximum of three successive high pressure ventilation periods (HPVP) for 60 sec, RR of 10/min, I:E 1:1; ***RM-1):*** PEEP of 25 and PIP of 60 cm H_2O ***RM-2):*** PEEP of 35 and PIP of 60 cm H_2O, ***RM-3):*** PEEP of 45 and PIP of 60 cm H_2O. Each HPVP was followed by protective ventilation (PV): RR of 30/min, I:E 1:1, PIP of 35 cm H_2O, PEEP LIP + 2 or 22 if LIP was ≥ 21 cm H_2O. A successful RM was defined as a PaO_2 ≥ 400 mm Hg after 5 min. After each RM and 20 min of PV the lung was derecruited to the BL. The order of RMs was randomized in each animal.

Results: During RM-1 HPVP was performed 11x; during RM-2 9x; during RM-3 13x. One animal developed a pneumothorax. There was no statistical difference between the three RM regarding: PaO_2, $PaCO_2$, V_t, blood pressure, heart rate and cardiac output.

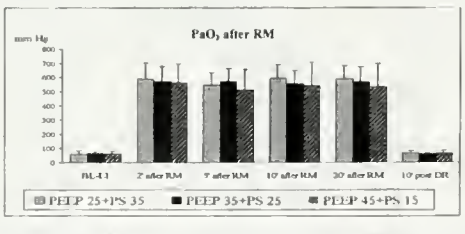

Fig1: PaO_2 levels after RM during PV (mean ±SD for all animals)

Conclusion: High pressure RM is not affected by PEEP, if the PEEP level is high enough to avoid collapse of recruited lung (PEEP ≥ LIP). We considered RM-1 optimal because of the lower mean airway pressure.

Reference: 1. Y Fujino et al.: Repetitive high-pressure recruitment maneuvers required to maximally recruit lung in a sheep model of acute respiratory distress syndrome. Crit Care Med 2001 Vol.29 No. 8 (in press)

OF-01-220

COMPARISON OF PERFORMANCE CHARACTERISTICS FOR PROPORTIONAL ASSIST VENTILATION (PAV) IN TWO DIFFERENT VENTILATORS. A LUNG MODEL STUDY.

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Proportional assist ventilation (PAV) is a new mode of mechanical ventilation, devised to increase airway pressure in proportion to patient effort. . This is accomplished by a positive feedback control that amplifiers airway pressure proportionally to instantaneous inspiratory flow rate and volume. Since PAV may soon become an available option to treat patients with respiratory failure, the present lung model study was designed to compare the function of PAV under a variety of loading conditions in two ventilators: Evita-4 (Drager) and Vision (Respironics). **Methods:** A two-compartment spontaneously breathing LM (Michigan, TTL model 1600) was used. One chamber of the LM (resistance of 5 H_2O/l/sec, compliance of 80 ml/cm H_2O) was connected to the tested ventilator, the second was driven by a Puritan Bennen 7200 ventilator to simulate the following spontaneous breathing pattern: T_I =0.8 sec, RR of 12 breath/min, and peak inspiratory flow of 60 l/min. We compared three different levels of PAV 80%, 50% and 30% on each tested ventilator. **Results:** Data (mean ± SD) are listed in following table.

	Volume (ml)	Peak Press (cm H_2O)	Peak Flow, (l/min)	Flow after 0.1 sec (l/min)	PTP (cm H_2O· sec/min
Vision PAV 80%	620 ± 0	14.3 ± 0.2	105 ± 1	64.9 ± 1.1	4.6 ± 0.3
Evita-4 PAV 80%	650 ± 0	19.0 ± 0.1	108 ± 1	21.2 ± 0.4	18.0 ± 0.4
Vision PAV 50%	600 ± 0	9.8 ± 0	88 ± 1	62.2 ± 3.1	5.7 ± 0.1
Evita-4 PAV 50%	610 ± 0	12.6 ± 0	95 ± 1	25.4 ± 0.6	19.2 ± 0.3
Visinn PAV 30%	580 ± 0	7.6 ± 0	79 ± 0	64.6 ± 1.8	8.3 ± 0.2
Evita-4 PAV 30%	580 ± 0	9.0 ± 0	87 ± 0	25.8 ± 0.2	21.2 ± 0.3

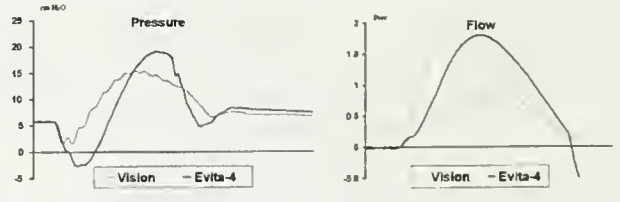

Fig.1: Pressure and flow waveforms for Vision and Evita-4 at PAV of 80%

Conclusions: During all settings of ventilatory support (PAV 80-30%) PTP was lower with the Vision ventilator as a result of higher flow acceleration and better trigger performance.

OF-01-221

TRACHEAL GAS INSUFFLATION (TGI) DURING PRESSURE CONTROL VENTILATION (PCV): EFFECT OF EXHALATION VALVE CONTROL.

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BACKGROUND: TGI may be useful in patients with elevated $PaCO_2$. TGI lowers $PaCO_2$ and reduces deadspace ventilation by flushing CO_2 from the upper and artificial airways during exhalation and by augmenting V_T delivery at the tracheal level. We designed a lung model study to evaluate the effect of TGI on V_T and airway pressure delivery during PCV with four acute care vents. **METHODS:** Four vents with PCV were evaluated: 300 (Siemens), and 840 (Puritan-Bennett), Evita 4 (Drager), Galileo (Hamilton Medical). Each vent was set to ventilate one side of a two chamber test lung (TTL, Michigan Instruments) at compliance (C)/resistance (R) combinations of: 20/5, 20/20, and 50/20. An 8-mm ET tube was inserted into an artificial trachea and TGI was provided via a 2.9 mm ID catheter positioned with the tip 2 cm beyond the end of the ET tube. TGI continuous flows of 0, 4, 8, and 12 LPM were used. Each vent was set to a CMV rate of 15, PCV (ΔP) of 20 cmH_2O, PEEP of 10 cmH_2O. Inspiratory time (T_I) was set to 1.0 and 2.0 seconds. A pneumotach and pressure transducer were placed between the trachea and test lung to measure flow, volume, and pressure delivered to the lung. Peak inspiratory pressure and V_T measured by each vent were also recorded. Five breaths at each condition were recorded. **RESULTS:** Table 1 shows the V_T delivered to the lung and measured V_T by each vent at baseline and with 12 lpm TGI flow at each T_I (C20, R20).

Table 1	TGI Flow	T_I = 1 sec		T_I = 2 sec	
		V_T (vent)	V_T (lung)	V_T (vent)	V_T (lung)
300	0	461	387	468	404
	12	1003	411	996	537
840	0	409	388	427	400
	12	976	423	812	444
Evita 4	0	443	383	443	389
	12	963	403	965	421
Galileo	0	449	397	438	398
	12	991	443	982	575

Vents (840, Evita 4) with "active" exhalation valves, limit delivery of additional V_T to the lung during TGI by "bleeding off" TGI flow once vent flow output reaches zero. Alveolar pressure is maintained at the preset level throughout T_I. Vents (300, Galileo) without "active" exhalation valves force TGI flow into the lung during T_I. This results in increased alveolar pressure and V_T, when C_{RS} is low and T_I is long. **CONCLUSIONS:** Active exhalation valves limit alveolar pressure during TGI and thus limit V_T as compared to exhalation valves that are not active. Clinical investigations are necessary to elicit the effects of exhalation valve control on ABGs and pulmonary variables during TGI with PCV.

OF-01-246

EFFECT OF INTERNAL AND EXTERNAL NEBULIZER FLOW ON TIDAL VOLUME (V_T) DELIVERY DURING MECHANICAL VENTILATION (MV).

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BACKGROUND: Delivery of inhaled medication is common during MV. Many new vents provide an internal neb (INT NEB) that provides preset neb flow during inspiration. A continuous externally provided gas flow is used to power a neb (EXT NEB) on vents that do not have an INT NEB. We designed a bench study to evaluate the volume and pressure delivery to the lung during use of both INT NEB and EXT NEB use and to determine the effect of ventilator mode. **METHODS:** Five vents were evaluated: 300 (Siemens), 840 and 7200 (Puritan-Bennett), Evita 4 (Drager), and Galileo (Hamilton Medical). Each vent was set to ventilate one side of a two chamber test lung (TTL, Michigan Instruments) at a compliance (C) of 50 ml/cmH_2O and resistance (R) of 20 cmH_2O/L/sec. Vents were set to a CMV rate of 15, PEEP of 10 cmH_2O, FiO_2 of 0.80, and inspiratory times (T_I) of 1.0 and 2.0 sec. Three modes were tested: VCV set to 450, PCV set to ΔP of 20 cmH_2O, and dual control (DC) with V_T target of 450. A pneumotach and pressure transducer were placed between the circuit and TTL to measure flow, volume, and pressure delivered to the lung. Peak inspiratory pressure and V_T measured by each vent was also recorded. FiO_2 entering the TTL was measured using a Zirconium O_2 analyzer. Data was recorded at baseline (no neb), with INT NEB on, and with EXT NEB flow of 8 lpm (O_2). All neb flow was injected into the inspiratory limb, 10" prox to the wye, via a Mini-neb (Salter Labs). Five breaths at each condition were recorded. **RESULTS:** Only 7200, Evita 4, and Galileo have INT NEBs. V_T delivery to the lung increased by 27 ± 1% and 52 ± 1% during VCV with the Galileo with T_I of 1 and 2 sec, respectively with INT NEB. INT NEB use did not change lung V_T by more than 8% with any other vent or mode use. INT NEB use did not result in large changes in FiO_2 (> 3%) with any vent or mode tested. Use of EXT NEB with VCV increased lung V_T by 36 ± 4% with T_I of 1 and by 64 ± 8% with T_I of 2 (all vents). EXT NEB used with PCV increased lung V_T by 14 ± 2% at T_I of 1 (7200) and by 13 ± 2% at T_I of 2 (300, 7200, Evita 4). EXT NEB used with DC increased lung V_T by 35% ± 3 at T_I of 1 and by 62% ± 4 at T_I of 2 (300, 840, E4). EXT NEB caused an average increase in FiO_2 of 14 ± 4% (300, 840, 7200, Galileo). EXT NEB caused FIO_2 to increase by 22 ± 3% with the Evita 4. Vent measured V_T was within 10% of delivered V_T for all vents with NO NEB or with INT NEB use. Galileo measured V_T was within 10% of delivered at all settings. Measured V_T exceeded delivered V_T by > 50% when EXT NEB was used with the 300, 840, 7200, and E4 with all modes and T_Is. **DISCUSSION/CONCLUSION:** The INT NEB on the Galileo is not "volume compensated", resulting in additional V_T delivery during VCV. EXT NEB increases delivered V_T in all cases, except PCV with T_I of 1 (all vents), PCV with T_I of 2 (840, Galileo), and DC with T_I of 1 and 2 (Galileo). Clinicians should be aware that delivery of inhaled medication by nebulization may affect the measurement and delivery of V_T and FiO_2 differently, depending on the vent used, mode employed, Ti, and NEB delivery technique.

OF-01-249

EFFECT OF TRACHEAL GAS INSUFFLATION (TGI) DURING DUAL CONTROL (DC) VENTILATION.

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BACKGROUND: TGI may be useful in patients with elevated $PaCO_2$. TGI lowers $PaCO_2$ and reduces deadspace ventilation by flushing CO_2 from the upper and artificial airways during exhalation and by augmenting V_T delivery. We designed a lung model study to evaluate the effect of TGI on V_T and airway pressure delivery to the lung during ventilation with four DC modes. **METHODS:** Four DC modes were evaluated: Adaptive Pressure Ventilation (APV, Galileo, Hamilton), AutoFlow (AF, E4, Drager), Pressure-Regulated Volume Control (PRVC, 300, Siemens), and VolumeControl Plus (VC+, 840, Puritan-Bennett, pre-release software*). Each vent was set to ventilate one side of a two chamber test lung (TTL, Michigan Instruments) at compliance (C - cc/cmH_2O) / resistance (R - cmH_2O/L/sec) combinations of: 20/5, 20/20, and 50/20. An 8-mm ET tube was inserted into an artificial trachea and TGI was provided via a 2.9 mm ID catheter positioned with the tip 2 cm beyond the end of the ET tube. TGI continuous flows of 0, 4, 8, and 12 LPM were used. Each vent was set to a CMV rate of 15, target V_T of 450 ml, PEEP of 10 cmH_2O. Inspiratory time (T_I) was set to 1.0 and 2.0 seconds. A pneumotach and pressure transducer were placed between the trachea and test lung to measure flow, volume, and pressure delivered to the lung. Inspiratory and expiratory V_T, inspiratory and expiratory flow, and peak and baseline pressure measured by each vent were also recorded. Five breaths at each condition were recorded. **RESULTS:** Table 1 shows the V_T delivered to the lung and measured exhaled V_T by each vent at baseline and with 8 lpm TGI flow at each T_I tested (C50, R20).

Table 1	TGI flow	T_I = 1 sec		T_I = 2 sec	
		V_T (vent)	V_T (lung)	V_T (vent)	V_T (lung)
300	0	466	388	475	402
	8	1032	549	1023	672
840	0	433	424	433	431
	8	1044	654	1032	736
Evita 4	0	434	382	444	399
	8	988	511	996	620
Galileo	0	449	439	423	419
	8	567	224	570	329

Vents (840, 300, Evita 4) that use inspiratory V_T as the target during DC do not adjust flow output in the presence of TGI flow. This results in an increased V_T delivery to the lung, which is dependent on TGI flow, T_I, and C. Vents (Galileo) that use measured exhaled V_T as the target during DC reduce flow output and thereby V_T delivery to the lung in the presence of TGI flow. Measured V_T may exceed delivered V_T by as much as 50% in the presence of TGI flow. **CONCLUSIONS:** DC algorithms vary by manufacturer and will effect the V_T delivery to the lung in the presence of TGI flow. Practitioners should familiarize themselves with DC algorithms prior to clinical use.

OF-01-250

THE EFFECT OF INSPIRATORY RISE TIME ON TOTAL PATIENT WORK OF BREATHING (TPWOB) DURING PRESSURE SUPPORT VENTILATION (PSV) IN A SPONTANEOUS BREATHING LUNG MODEL

David L. Vines, MHS, RRT, Warren Kolenda, CRT, Faustino Ramos, CRT, David C. Shelledy, PhD, RRT. The University of Texas Health Science Center, San Antonio, Tx. **BACKGROUND:** Limmited information is available concerning the use of rise time on the SERVO 300 ventilator (SiemensMedical, Danvers, Massachusetts). We compared various rise time settings during PSV to determine which setting resulted in the lowest TPWOB using a two-compartment mechanical lung model (Michigan Instruments Inc., Grand Rapids, MI) to simulate spontaneous breathing. **METHODS:** WOB was first measured on lung B alone at tidal volumes of 200, 400, 600, and 800 while peak flow was varied from 30, 60, 80, and 100 L/min with a sine wave flow pattern using the Ventrak 1550 Respiratory Mechanics Monitoring System (Novametrix Medical Systems, Inc., Wallingford CT). Then WOB was measured at these volumes for lung B to drive lung A at normal compliance (0.05 L/cmH2O) and resistance (2.7 cmH2O/L/sec), decreased compliance (0.02 L/cmH2O), and increased resistance (17.6 cmH2O/L/sec) while lung A received assistance through an 8.0 endotracheal tube from either PSV of 5, 10, 15 or 20 cmH2O, while the rise time setting was varied from 0 to 10 for each level of PSV. TPWOB was calculated using the following formula: [TPWOB= $WOB_{(B+A)}$ - WOB_B] **RESULTS:**

Mean WOB (J/L)			
Rise Time	Normal C/R	↓C	↑ R_{aw}
0	0.34 (0.31)*,**,***	0.83 (0.44)*,**	0.64 (0.42)*,**
2	0.42 (0.33)*,**	0.90 (0.43)*	0.73 (0.43)
5	0.50 (0.34)	0.99 (0.44)	0.81(0.44)
8	0.58 (0.36)	1.05 (0.43)	0.87 (0.45)
10	0.63 (0.37)	1.10 (0.43)	0.92 (0.45)

+ significantly < rise time–10, $p<0.05$, ++ significantly < rise time–8, $p<0.05$, +++ significantly < rise time–5, $p<0.05$. **CONCLUSION:** The lower the rise time the lower TPWOB in our spontaneous breathing model. A rise time setting of 0 should result in lowest TPWOB under most patient conditions.

OF-01-267

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THE EFFECT OF PULMONARY REHABILITATION ON THE NUMBER OF PATIENT VISITS AND HOSPITAL ADMISSIONS

Wayne Wallace BA, RRT, Wes Cowan, BS, RRT, Peter Wang, BS, RRT, Jerry Lisicki, RRT, RPFT,& Thomas Mahrer MD
Kaiser Permanente Los Angeles Medical Center, Los Angeles, CA

BACKGROUND. Patients experiencing chronic lung disease place a great strain on the health care system. In order to mitigate the deleterious effects of over utilization, pulmonary rehabilitation programs have been established. These programs emphasize education and exercise to decrease pulmonary patients' underlying debilitation. However, does pulmonary rehabilitation reduce the number of out patient visits and hospital admissions relating to lung disease? METHODS: 27 consecutive patients suffering from chronic lung diseases were enrolled in the pulmonary rehabilitation program. The program consists of 3 sessions a week for 6 consecutive weeks. The patients participate in a progressive exercise program followed by a mini-lecture of interest to chronic pulmonary patients. The number of outpatient visits, emergency department visits, and hospital admissions that were related to lung disease were tabulated for a year before and after enrollment in the pulmonary rehabilitation program. RESULTS: The results are summarized in the following table. A paired student's T-test for the total number of visits was significant at p=0.0002. The mean number of visits dropped from 2.59 visits patient per patient prior to enrollment in the pulmonary rehabilitation program to 1.33 visits per patient after participating in pulmonary rehabilitation.

Utilization of Services

Visit Type	Prior Visits	Post Visits	*p-value*
Clinic	60	25	0.0001
ED	6	8	0.2868
Admissions	4	3	0.2868
Total	70	36	0.0002

EXPERIENCE: A well-designed pulmonary rehabilitation reduces chronic lung disease patient's utilization of the physician clinic. CONCLUSIONS: There was a reduction in physician clinic utilization. However, there was no reduction in the overall numbers of hospital admissions or visits to the emergency department.

OF-01-018

EFFECTS OF OUTPATIENT PULMONARY REHABILITATION ON THE PSYCHOLOGICAL AND PHYSIOLOGICAL ASPECTS OF QUALITY OF LIFE AS MEASURED BY THE SF-36

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INTRODUCTION In the United States, approximately 12.5 million people suffer from chronic bronchitis and 1.65 million from emphysema, totaling 14 million people with COPD. The belief that there is little hope for improvement in patients with advanced chronic respiratory disease is no longer true because pulmonary rehabilitation is now part of the clinical management and health maintenance of these patients. Its affect on psychological and physiological aspects of quality of life can be measured using the short form 36 (SF-36) questionnaire. Our null hypothesis for this study was that pulmonary rehabilitation produces no change in psychological or physiological aspects of quality of life as measured by the SF-36. **METHODS** The 87 subjects were a convenience sample of patients in an outpatient rehabilitation program, between the ages of 45 and 80. The SF-36 scores were taken before and after pulmonary rehabilitation. We considered results for the eight domains on the SF-36 test: physical functioning, role functioning, bodily pain, general health, vitality, social functioning, role emotional and mental health. The paired groups t-test was used to compare pre and post-rehab scores, and the independent groups t-test was used for gender comparisons. The significance level was $p \leq .05$ **RESULTS** The SF-36 scores showed a significant improvement in seven of the eight domains. The change in the bodily pain domain was not significant. There was not a significant difference in scores between males and females. **CONCLUSION** The subjects showed significant improvement in their psychological and physiological status following pulmonary rehabilitation. The null hypothesis was rejected.

Pre and Post Rehabilitation SF-36 Scores

Domain	Pre Rehab Mean	Post Rehab Mean	*p*-Value
Physical Functioning	31.06	42.49	0.000
Role Functioniog	32.66	54.60	0.000
Bodily Pain	69.32	70.84	0.509
General Health	44.28	49.43	0.098
Vitality	40.02	52.06	0.000
Social Functioning	62.64	78.91	0.000
Role Emotional	49.48	74.86	0.000
Mental Status	68.79	75.99	0.000

OF-01-034

COMPARISON OF CHEST PHYSIOTHERAPY, FLUTTER, AND PEP

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Abstract:. This study was undertaken to determine the efficacy and costs associated with the flutter device (Flutter) and pep device (PEP) as compared to conventional manual chest physiotherapy (CPT) in hospitalized adult patients undergoing an acute COPD exacerbation, pneumonia, or post-surgical bronchial hygiene. CPT is defined as therapy incorporating postural drainage, percussion and vibration as put forth in the American Association of Respiratory Care (AARC) Clinical Practice Guidelines. **Design**. Data was extracted from the Clinivision Charting System used by the Respiratory Care Department. The parameters measured were improved breath sounds post treatment, sputum produced post treatment and the actual treatment time. The staff was unaware of the data collection or study goals. The devices used as alternatives to CPT were the Flutter® by Scandipharm and the Threshold PEP® by HealthScan. These devices were selected by meeting criteria for ease of use and cost to the institution. **Participants**. 708 adult patients over a period of one year with a primary diagnosis or admission for either COPD Exacerbation, pneumonia, or surgical/trauma. **Interventions**: Patients were assessed for modality via the secretion management indicators taken from the American Association for Respiratory Care (AARC) Clinical Practice Guidelines. The patients were instructed and supervised by Respiratory Care Practitioners (RCP's) when performing Flutter or PEP. All patients were monitored for complications or adverse reactions to therapy (hemoptysis, hypoxia, increased ICP, pneumothorax, etc.). **Results**: CPT, Flutter and PEP all performed at the same level (65 – 68% positive) for the category of Improved Breath Sounds Post Treatment. CPT and Flutter were identical (21% positive) for Sputum Production Post Treatment with PEP data being lesser (12% positive). Length of Treatment Time was measured with the average length of a CPT session being just under 17 minutes. The Flutter averaged about 12-1/2 minutes and the PEP measured almost 13-1/4 minutes. **Experience**: Ease of training for the caregiver is significant. Staff was inserviced in less than one hour and able to deliver therapy to patients immediately. Both Flutter and PEP can be taught to appropriate patients and can be continued past the hospital experience. Staff reported patient satisfaction and positive physiological responses to these therapies as well as simplicity of teaching to patients and families. **Summary**. Flutter appears to be equally as effective as CPT when used as bronchial hygiene therapy for the promotion of sputum mobilization and improved breath sounds. PEP did not perform quite as well when one looks at the sputum mobilization criteria. However, the numbers of treatments using PEP were significantly less than the Flutter or CPT and this may be why the sputum produced results are not equal. In addition to the cost savings demonstrated in the time factor, this PEP device is significantly less costly as compared to the Flutter device. In addition, this PEP device can be placed in line with a Medication Nebulizer treatment for appropriate patients. This may further enhance the medication delivery as well as reduce costs for the facility. Further study of this aspect of use is indicated.

OF-01-048

NON INVASIVE VENTILATION ALLOWING A FAST PULMONARY REHABILITATION PROGRAM OF A CHRONIC OBSTRUCTIVE PULMONARY DISEASE CASE.

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The impaired exercise tolerance in chronic obstructive pulmonary disease (COPD) patients is pivotal to worsen the pulmonary disease and the persistent state of muscular deconditioning resulting in a extremely sedentary lifestyle. Initially, these patients experience dyspnea on exertion because of defective respiratory mechanics, poor diffusing capacity, compromised gas exchange, and elevated dead space to tidal volume ratio. However, dyspnea becomes the feared result of any attempt to exert. This sets up a mutually reinforcing cycle between inactivity and physical deconditioning. The non invasive ventilation (NIV) is a supportive therapeutic method very useful to allow the inclusion and progression of COPD patients in a rehabilitation program despite few reports in literature using this device during the training. The NIV offers a support to the respiratory muscle weakness, reversing partially the overload imposed to ventilatory muscles due to the impared lung mechanics. This case is of a 64-year-old patient, weighting 92 Kg, body mass index (BMI= 33.8 Kg/m^2), with a moderate overlap syndrome (PO_2=52 mm Hg, PCO_2= 49 mmHg, SO_2=88%, FEV_1=1.34L) and with hypertension and nefropaty as comorbid conditions, oxygen-dependent (using 2L/min). The medical treatment involved the prescription of inhaled bronchodilators (β agonists) and anti-hypertensive drugs (diuretic and angiotensin-coverting enzyme inhibitor). The patient in this case had a severe functional limitation to normal daily activities with scores based on the Chronic Respiratory Disease Questionnaire (CRDQ). The NIV was used to start a two-month aerobic training, five times a week in the treadmill with intensity ranging from 60 to 70% of the maximum heart rate reserve. Dyspnea sensation was also evaluated with the BORG scale during the training. As the patient improved his exercise tolerance the support pressure levels were decreased from 14 to 6 cm H2O until the patient was able to perform the training without the NIV safely. In addition, it was increased the speed (from 2.6 miles to 2.9 miles per hour) and training time (from 4 to 40 minutes). Nowadays, the patient has been performing one hour of aerobic training per day which also includes the inespecific muscle training (upper and lower-extremity training with a 1.5 Kg load) and the ventilatory muscle training using the threshold device. The last gasometric results were PO_2= 68mm Hg , PCO_2= 39mm Hg , SO_2= 93.4% and his present weight is 80 Kg (BMI= 29,4 Kg/m^2). Overall, the patient has got a great improvement on his exercise performance and symptoms and therefore, recovered his ability to perform the normal daily activities with better quality of life (CRDQ).

OF-01-076

HEALTH BEHAVIORS OF REHABILITIATION THERAPISTS IN A LONG TERM ACUTE CARE FACILITY

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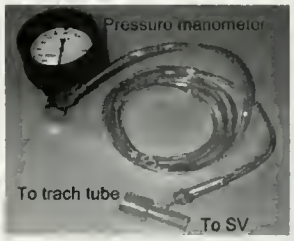
Patients who enter a rehabilitation long-term acute care facility are admitted for the reason of rehabilitation and ventilator weaning. One of the main reasons for the present state of health of these patients can be attributed to health risk behaviors. Smoking is known to be associated with pulmonary disease and lung cancer. Drinking alcohol in excess, poor diet and poor exercise habits are also associated with diseases of the liver, heart, and pancreas. One of the roles of a rehabilitation therapist is patient health education. A modified Youth Risk Behavior Survey for college students (YRBS-C) was administered to twenty therapists and other health care professionals working in a twenty-two bed acute care long term facility. The YRBS-C had been developed to determine the health behaviors of college students that contribute to the leading causes of mortality and morbidity among youth and adults in the United States. Nineteen of the questionnaires were returned. Nine of the respondents identified themselves as respiratory therapists. The majority of the participants were female, married, mean age of thirty- eight years, and White-not Hispanic. The mean number of years of the respondents working in their professional field was 11.6 years, with a mean level of education beyond high school of 3.8 years. Ten of the respondents reported to have ever smoked cigarettes regularly. Half of the confirmed smokers have tried to quit cigarettes in the past 6 months. Eight of the respondents reported not to have had a drink of alcohol during the past 30 days. One of the respondents reported to drink at least one drink a day. Sixty-three percent of the respondents felt their weight to be overweight. Over half of the respondents were trying to lose weight. Only sixteen percent of the respondents did not eat fruits daily, close to half report eating green salad daily, and close to seventy-five percent eat cooked vegetables daily. Seven respondents did not partake in any form of aerobic activity, seventy-four percent do no strengthening or toning exercises and forty-two percent reported not to have walked or ride a bicycle for at least 30 minutes that week when questioned. There was s significant negative correlation between the smoking and educational attainment years (-.732), a lesser degree of relationship between diet and educational attainment years (.622), and a lesser negative relationship between diet habits and smoking (-.587). Questions to be explored in the future are: Do therapists who possess "good health behaviors" have more impact on the patient and their rehabilitative care and education? Should professional training programs devote more time to the teaching of health risk behaviors in order to help produce "healthy" therapists?

OF-01-081

ASSESSMENT OF EXPIRATORY TRACHEAL PRESSURE WITH USE OF A SPEAKING VALVE. Christopher Piccuto RRT, Daniel Chipman RRT, Douglas Johnson MD, Robert Kacmarek PhD RRT FAARC, Dean Hess PhD RRT FAARC. Massachusetts General Hospital and Harvard Medical School

Speaking valves (SV) are commonly used to promote exhalation through the upper airway for patients with tracheostomy. We have been concerned that patients occasionally experience expiratory resistance when the SV is placed. Therefore, we assessed the utility of measuring expiratory tracheal pressure as an objective indicator of expiratory resistance when a SV is placed. **Method:** Before placing the SV, an assessment of the appropriateness of placing it was made by a respiratory therapist. If present, the cuff was deflated. In the case of a fenestrated tube, the inner cannula was removed. Secretions were cleared as needed. The set-up shown in the figure was then used to measure expiratory tracheal pressure with the SV in place during relaxed breathing. After the pressure measurements, the manometer was removed and the SV attached directly to the tracheostomy tube.



Results: Assessments were made in 37 patients. The expiratory pressure was ≤5 cm H_2O in 75% of cases and ≤10 cm H_2O in 90% of cases. Pressures >10 cm H_2O were associated with clinical evidence of respiratory distress and the SV was immediately removed. There was no difference in expiratory pressures for fenestrated tubes (n=18, 5.9±7.0 cm H_2O) and nonfenestrated tubes (n=19, 5.7±4.5 cm H_2O)(P=0.94). Expiratory pressures were greater for larger tubes (ID 7 and 8 mm, n=21, 7.0±6.8 cm H_2O) than smaller tubes (≤ 6 mm ID, n=16, 4.3±3.8 cm H_2O), but this was not statistically significant (P=0.13). **Conclusions:** Tracheal pressure measurements are a useful objective measure of expiratory resistance when a SV is used. Expiratory tracheal pressures ≤5 cm H_2O are common with the SV in place and seem to be well tolerated. We did not identify immediate clinical symptoms with pressures ≤10 cm H_2O. Pressures >10 cm H_2O are not tolerated. With high pressures, the SV should be promptly removed, and causes of expiratory resistance should be investigated such as a large tracheostomy tube or upper airway pathology. Downsizing to a tube with a smaller outer diameter should be considered. It is interesting to note that we found no difference in expiratory tracheal pressures with fenestrated or nonfenestrated tracheostomy tubes and a SV in place.

OF-01-144

PERFORMANCE AND WEIGHT COMPARISON OF PORTABLE OXYGEN SYSTEMS

Bliss PL, McCoy RW. Valley Inspired Products, Burnsville MN

Background: Recently, new systems for portable oxygen delivery have been introduced to allow long term oxygen therapy (LTOT) patients greater mobility. Much of the improvement in weight and use time comes through the use of Demand Oxygen Delivery Systems (DODS). Each model of device delivers oxygen in a different manner, and settings are not absolutely comparable to continuous flow oxygen (CFO) or to each other. We evaluated a measure of system portability, use time per unit weight, at comparable FIO_2 levels, using a mechanical lung simulator. Three newer sytems were compared with two more traditional, CFO delivery systems. **Methods:** An apparatus was constructed to simulate the nares, conducting airways and an alveolar chamber with a machined 'nose', flex tube (150 ml of deadspace) and a spontaneous breathing simulator (Hans-Rudolph Series 1100). A simulated respiratory pattern (VT=515 mL, f=20/min, I:E=1:2, decelerating flow wave) was generated. The oxygen delivery setting of each device was adjusted to attain as close to 27% FIO_2 delivery to the alveolar chamber as possible, measured with an oxygen analyzer (Douglas Scientific). Oxygen pulses from the DODS were measured by a mass flowmeter (Model 4040 - TSI). The maximum FIO2 attainable with each device was measured (the highest deliver setting). Devices tested were Chad Therapeutics TotalO2 301 system with M6 cylinder, Mallinckrodt Helios, Invacare Homefill II with M6 cylinder, Caire Stroller (continuous flow) and an aluminum 'E' cylinder with aluminum regulator. Systems were weighed when full with oxygen and including any carrying bag or straps (cart for 'E' cylinder). **Results:**

Device	Setting	FIO_2 %	Device Weight lbs	Use Time hours	Hours/lb	MAX FIO_2 %
Stroller CFO	2	27.2	8.6	7.2	.83	39.6
E Cylinder CFO	2	27.2	15	5.3	.35	39.4
TotalO2	3	27.9	5.7	4.4	.77	30.4
Helios	3	26.8	4.0	6.4	1.6	28.0
Homefill II	2.5	26.8	5.6	3.3	.60	34.5

All DODS triggered their oxygen delivery as anticipated. Higher DODS settings were required to attain similar FIO_2 values to CFO. Not all devices had a setting to exactly match the FIO_2 of CFO, which affects the use time and calculated Hours/lb.. **Conclusion:** New options for LTOT patients can provide significantly lighter oxygen systems with the comparable use times. The Helios system stands out as being much more weight efficient than other systems, but is limited in its maximum FIO_2 delivery capability.

OF-01-162

PERFORMANCE OF FOUR AUTO-TITRATING CPAP DEVICES IN A SIMULATION OF VARIED PATIENT BREATHING

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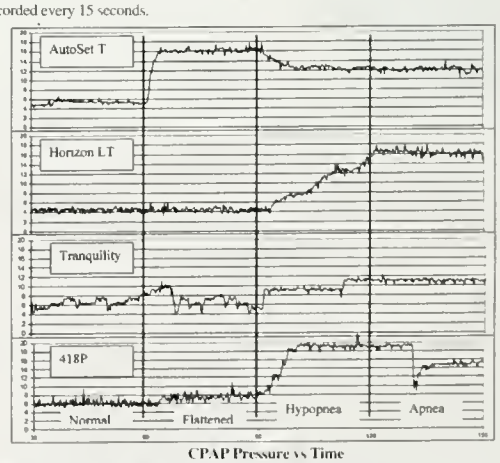
Background: Automatic titrating CPAP devices for treatment of sleep apnea have been introduced in recent years. These devices monitor patient breathing, and respond to a variety of perceived patterns by adjusting the pressure up or down as deemed appropriate. Several clinical studies have demonstrated the effectiveness of these devices, yet little is known about the mechanisms they use to determine treatment, or differences between devices. **Methods.** Four commercially available "auto-CPAP" products were challenged with a mechanical breathing simulator (Hans Rudolph Inc. Series 1101). Breathing patterns were recorded on patients undergoing polysomnographic study. The resulting flow waveform was 'played back' by the breathing simulator. Four patient recorded waveforms were selected for a unique quality, 'normal breathing', flow limited or flattened waveform, hypopnea and apnea. The devices were subjected to the patterns for one half hour each. Pressure at the mask was recorded every 15 seconds.



CPAP Pressure vs Time

Discussion: Of the myriad of factors evaluated by 'auto-CPAP' devices, only four patterns were tested. In addition, patient adaptation was not allowed for. **Conclusion:** Devices varied markedly in their response to patient breathing patterns. There is lack of standardization methods employed by auto-CPAP devices. It is expected that different patients will have varied experience depending on which device they are treated with.

OF-01-163

Chronic obstructive pulmonary disease prevalence in workers of rubber plantations in South Vietnam

Le Thi Tuyet Lan – Vo Minh Vinh

The aim of this study is to determine the prevalence of COPD in workers of rubber plantations in South Vietnam.
1053 workers of 6 rubber plantations in South Vietnam have been selected by stratified random method, including 559 males (53.09%) and 494 females (46.91%). The age of workers in this study is from 18 to 61 years old.
1.89% of workers are exposed to insecticides and 27.07% to H_2S, ammonia and acetic acid. All female workers are exposed to wood-cooking fumes at their homes.
The rate of female smokers is only 1.4% while that of male is up to 94.1%. There are 39% of male workers who have smoked before 18 years old and among them 14% have smoked before 15 years old. 22% of male workers have smoked more than 20 pack-years. All workers were interviewed by physicians to fulfill the British Medical Research Council questionnaires, undergone clinical examinations and spirometric tests, which adhered to the method of ATS, 1994. COPD was defined as $FEV_1/VC < 70\%$, no significant response to short acting β_2-agonist and clinically correlated. Chest x-rays were performed for patients who met three of the above criteria to rule out other diseases before the diagnosis of COPD was made. For COPD patients of stage 2 and 3, blood gas analysis were done.
The classification of COPD severity is based on % FEV_1 predicted. The predicted values are that of Asian people. The result is shown in the following table:

Table 1. ***Prevalence and staging of COPD in 1053 workers of rubber plantations in South Vietnam***

Stage	Characteristics	females n (%)	males n (%)
0	Normal spirometry Chronic cough and sputum production	9 (1.82)	24 (4.24)
1	$60\% \le FEV_1 < 80\%$ predicted	12 (2.43)	47 (8.31)
2	$40\% \le FEV_1 < 60\%$ predicted	1 (0.20)	4 (0.70)
3	$FEV_1 < 40\%$ predicted	1 (0.20)	1 (0.77)
	Total	23 (4.65)	76 (13.42)

South Vietnam

FEV_1 : Forced expiratory volume in one second

Thus the prevalence of COPD in female rubber plantation workers is 4.65%, that of male 13.42% and of both gender is 9.03%.
This study showed how important are the smoking rate and COPD prevalence in male workers in rubber plantations in South Vietnam.
The need for helping them to quit smoking and early management of their COPD is urgent.

OF-01-164

EVALUATION OF A NEW DEMAND OXYGEN CONSERVATION DEVICE IN PATIENTS WITH CHRONIC LUNG DISEASES AT REST AND WITH EXERCISE

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Background: Oxygen therapy is an important treatment and has been shown to improve survival in hypoxemic COPD patients. Due to potential cost savings and portability benefits, demand oxygen systems have increased in use. Previous studies have demonstrated mixed results of conservation systems during exercise and with activities of daily living. We sought to evaluate use of an O_2XPRESS pneumatic device by comparing it to continuous flow during exercise in pulmonary rehabilitation program graduates.

Method: Twenty-one O_2 dependent patients (18 COPD, 3 Restricted lung disease) with documented hypoxemia on room air (SaO_2 <88% or PaO_2 55mmHg) were studied. All were receiving long term oxygen therapy. During the one visit testing, patients were provided with either a continuous flow nasal cannula or the Salter Labs demand oxygen conserving device (DOCD). Vital signs and oxygen saturations were assessed at rest and during exercise. While seated, subjects received sequential flow rates of 1, 2, 3 and 4 LPM of supplemental oxygen, once with continuous flow and once with the DOCD for 5 minute periods. Oximetry was recorded during the final 15 seconds of each five minute interval. Then subjects were tested while walking on the treadmill based on workload prescriptions determined during the previously completed pulmonary rehabilitation program. At UCSD, exercise training targets are set to approximate maximum symptom-limited levels reached during an initial incremental exercise test. In obstructive patients, supplemental oxygen was delivered sequentially, at 4, 3, 2, and 1 liters per minute during treadmill exercise for 3 minutes each. Following each change in flow rate subjects were required to rest for 10 minutes. Restrictive patients received higher flow rates, sequentially, at 6, 4, 2 and 1 LPM. Ratings of perceived breathlessness and muscle fatigue were also obtained via the Borg scale at the end of exercise. Assessments were terminated if oxygen saturations fell below 85%. COPD patients were analyzed in a group while the restrictive patients were studied individually. Repeated measures analysis of variance was used to compare oxygen saturation with the two methods of continuous flow via nasal cannula and the Salter Labs DOCD. Separate analysis was performed for rest and exercise with paired-t tests.

Results: For COPD patients, results showed there was no significant difference in SaO_2 at comparable flow rates between the two devices, although with exercise SaO_2 was significantly ($p < 0.05$) higher at the lowest flow rate with the DOCD (mean SaO_2 91.5% versus 90.2%). SaO_2 was higher for the DOCD in 10 patients (range 1-5%), higher for the nasal cannula in 4 (range 1-2%), and equal in 3 subjects. One subject did not exercise on 1 lpm due to a low SaO_2. Overall, there was no significant difference in ratings of muscle fatigue or breathlessness. Individual results for restrictive patients showed that at rest, the DOCD appeared to produce higher SaO_2 in one of three patients. During exercise there did not appear to be any consistent difference between continuous flow and use of the Salter Labs DCOD.

Conclusions: This pilot study demonstrated that the Salter Labs DOCD was comparable to continuous flow by nasal cannula at rest and during exercise in patients with chronic lung disease. It is important to note treadmill speeds in some patients were as high as 2.8 mph. Previous studies appear to have been conducted at much lower workloads. Since respiratory rates increase with higher workloads it is imperative that patients using conservation devices be assessed with exertion.

This study was supported by Salter Labs.

OF-01-193

A COMPARISON OF TWO HOME CARE CPAP SYSTEMS FOR MANAGEMENT OF INFANTS WITH TRACHEAL AND/OR BRONCHIAL MALACIA

Tom Blackson, BS, RRT, Christiana Care Health System, John Rendle, AS, RRT, Tim Cox, BS, RRT, A.I. DuPont Hospital for Children

Purpose: The purpose of this study was to evaluate two CPAP systems used for the home care management of an infant population of patients with airways compromised due to tracheal and/or bronchial malacia. **Design:** A bench model was developed using a drive ventilator to power one side of a Michigan test lung in order to simulate the breathing pattern of an infant. The drive side of the test lung was connected via the manufacturer supplied "bar" to slave the patient side to the drive side of the test lung. A 3.7 mm ID tracheostomy tube, along with a #20 parabolic resistor, was used on the patient side of the test lung in order to simulate a common artificial airway size and a "best circumstance" airway resistance. The patient side of the lung simulator mimicked a patient breathing at a respiratory rate of 30 breaths/min and a tidal volume of 50 ml. Four CPAP levels, (2.5, 5.0, 7.5, and 10.0 cm H_2O), were used for the comparison. Two different flow generators were employed, (device #1 & #2). The same external PEEP valves were used for both device evaluations. A free flow, zero PEEP, circuit was used as the control for each CPAP device. Values for total circuit flow, tidal volume, peak flow, minute volume, and extrinsic PEEP were obtained at each experimental PEEP level and control condition. A representative sample of the data collected is shown below for the extremes of PEEP settings as well as for the zero PEEP control.

Device #1

Circuit Flow L/min	V_T expired Patient ml	MV Patient L/min	PIF Patient L/min	PEEP Set cm H_2O	PEEP monitor cm H_2O
37.9 low	39	1.2	13.1	0	0.38
79.5 high	24	0.8	10.1	0	2.75
30.6 low	47	1.4	14.1	2.5	2.5
53.6 high	42	1.3	13.3	2.5	2.9
35.8 low	42	1.3	13.0	10.0	10.7
46.3 high	38	1.1	12.3	10.0	10.9

Device #2

Circuit Flow L/min	V_T expired Patient ml	MV Patient L/min	PIF Patient L/min	PEEP Set cm H_2O	PEEP monitor cm H_2O
12.9 Low	40	1.2	13.3	0	0
30.7 high	40	1.2	13.4	0	0
12.5 low	50	1.5	13.9	2.5	2.4
28.1 high	61	1.8	15.2	2.5	1.6
2.4 low	52	1.6	13.8	10.0	7.8
11.6 high	46	1.4	12.5	10.0	9.8

Conclusion: Selection of a home CPAP device may produce different patient responses despite standardization of the PEEP valve and patient drive to breathe. This may result in clinically significant differences in gas exchange and lung mechanics in the patient population in question. Further evaluation is indicated.

OF-01-216

BATTERY LIFE OF EIGHT PORTABLE VENTILATORS (PV): EFFECT OF CONTROL VARIABLE, PEEP, AND FIO_2.

Paul N. Austin PhD CRNA (Lt Col, USAF), Robert S. Campbell RRT FAARC, Gina M. Matacia, Gary Banks RRT, Jay A. Johannigman MD, Kenneth Davis Jr. MD, Fred A. Luchette MD, Sandra L. Miller MD, Richard D. Branson RRT FAARC. University of Cincinnati, Cincinnati, OH 45267-0558.

Background: Portable ventilators (PV) require battery power during transport or when AC power is unavailable. Manufacturers report battery life (BL) at nominal vent settings. We designed a bench study to evaluate the effects of control variable (pressure vs. volume), PEEP, and FIO_2 on BL of eight PVs. **Method:** Eight PVs were evaluated: Achieva (Puritan-Bennett), HT-50 (Newport), iVent 201 (VersaMed), LTV 1000 (Pulmonetics), T-Bird and Avian (Bird), and Unrvent 750 and 754 (Impact). Each PV with a fully charged battery was set to ventilate a test lung (TTL) at a rate of 10 bpm, tidal volume (V_T) 750 ml, inspiratory time of 1.5 sec with VCV and PCV (if available). FIO_2 was set at 0.21 and 1.0. PEEP was set at 0, 10 and 20 cmH_2O. TTL was set to compliance of 20 ml/cmH_2O and resistance of 5 cmH_2O/L/sec. Five trials with each PV were performed at each combination of settings. Time to low battery alarm, battery empty alarm, and failure to ventilate the TTL were recorded. Changes in PV performance during the trial were determined by continuous recording of V_T.
Results: Table 1 shows the BL for pneumatically powered PVs at various test conditions.

Table 1. BL in Mins. (Mean ± SD)	VCV, 100%, 0 PEEP	VCV, 100%, 20 PEEP	VCV, 21%, 0 PEEP
750	943 ± 84	920 ± 39	N/A
754	465 ± 16	435 ± 25	291 ± 2
Avian	893 ± 52	799 ± 42	N/A

Table 2 shows the BL for electrically powered PVs at various test conditions.

Table 2. BL in Mins (Mean ± SD)	VCV, 21%, 0 PEEP	VCV, 21%, 20 PEEP	PCV, 21%, 0 PEEP	VCV, 100%, 0 PEEP
Achieva	153 ± 4	130 ± 15	143 ± 6	150 ± 5
HT- 50	642 ± 38	388 ± 4	646 ± 69	N/A
iVent 201	57 ± 5	50 ± 9	55 ± 6	55 ± 1
LTV 1000	114 ± 6	72 ± 3	59 ± 7	94 ± 9
T-Bird	34 ± 4	19 ± 2	28 ± 1	29 ± 2

PEEP of 20 cmH_2O reduced BL on HT-50 (40%), LTV (37%), T-Bird (34%), and Achieva (15%) compared to 0 PEEP. PCV reduced BL on LTV (48%) and T-Bird (18%) compared to VCV. FIO_2 of 0.21 reduced BL on 754 (37%) compared to 1.0. FIO_2 of 1.0 reduced BL on LTV (17%) and T-Bird (15%) compared to 0.21. The iVent 201 was unable to deliver the set V_T with PCV and 20 of PEEP. Low battery alerms functioned properly on each PV. **Conclusion:** BL varies significantly among and between PVs. Clinicians must be aware that BL of PVs is affected by control settings and PV characteristics.

OF-01-247

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A Study of Patients Who Developed Post-Operative Atelectasis
An Outcome Measurement Perspective
George W. Lantz, B.S., R.R.T., C.P.F.T., R.C.P. Perinatal/Pediatric Specialist
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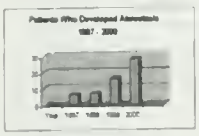
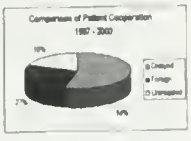
Background: Pursuant to monitoring performance improvement indicators and clinical statistics it was observed that there was an increasing incidence of post-operative atelectasis. A patient list was compiled covering a four-year period from 1997 through 2000 to determine the degree of increase and if there was a cause and effect relationship that could be identified and treated. Atelectasis is determined by increasing oxygen requirements, tachypnea, hypercarbia, pulmonary congestion and/or full or partial collapse of one or more lobes evidenced by radiological examination. **Findings:** It was discovered that the incidence of atelectasis increased 16% in 1998, 166% in 1999 and 366% in 2000 compared to 1997. Of these patients all but one received spinal surgery. As there are several stages/types of spinal surgery each of these were investigated without any significant difference between them or of the number of procedures performed. However, due to the impressive number of foreign patients and patients who have varying degrees of cerebral palsy these indicators were also investigated. 27% of the patients were foreign and 54% of the patients had developmental impairments that affected their ability to participate in their post-operative recovery. As these two indicators share the same outcome they were combined to reveal that 81% of all foreign/non-verbal patients receiving spinal surgery developed post-operative atelectasis. The results of these findings suggest that any foreign/non-verbal patient receiving spinal surgery have an 81% chance of developing post-operative atelectasis.





Conclusion: From this information it was determined that a protocol should be developed to treat this patient population proactively, avoiding said post-operative respiratory complications and henceforth reducing the amount of time spent in P.I.C.U. and the overall length of stay. Treatment options would include aggressive chest physiotherapy combined with PEP therapy (EzPAP) or IPPB Q4 hours for 48 hours then Q8 and *prn* for 48 hours then *prn* only for 48 hours. If the patient does not respond to the IPPB after 24 hours then consideration for BiPAP at night would be considered. It was determined that our foreign/non-verbal patient population who undergo all stages of spinal surgery are at the greatest risk for developing post-operative atelectasis. By proactively managing these patients with aggressive pulmonary hygiene and lung expansion therapy, a reduction in the incidence and severity of pulmonary complications as well as the costs and length of stay can be realized. Additionally, enhanced patient comfort and customer satisfaction will also reflect an enhanced dimension of patient care.

OF-01-003

Successful Multi-Organ Donation on ECMO Support
Douglas R. Hansell BS, RRT, John J McCloskey MD, Thomas Prankoff MD,
Michael H. Hines MD FACS

INTRODUCTION: There are currently over 73,000 patients with life-threatening illnesses awaiting kidney, liver, pancreas, intestine, lung and heart transplantation in the United States, while less than 22,000 transplants were performed in 1999. On average 13 people die each day while waiting for an organ, and a new patient is added to the list every 16 minutes. The main reason for this discrepancy is the severe shortage of donors. While efforts to increase donation as well as increase organ supply through xenograft research are underway, these will take time. Occasionally, patients supported on ECMO progress to brain death, despite excellent non-neurologic organ function and may be and the results of the donation.

METHODS: A 55 year-old white female presented to an outside institution with presumed pneumonia and worsening ARDS. She was transferred to our institution where she failed maximal support including antibiotics, inotropic support, high PEEP and ventilation with sedation and paralysis, and nitric oxide. She was placed on VV ECMO and the sedation and paralysis were discontinued. After failing to demonstrate any neurologic function once the medication had cleared, a CT scan was obtained demonstrating uncal herniation. A cerebral blood flow was obtained and demonstrated no flow. She was referred for organ donation after permission from the medical examiner. The family consented.

A 13 year-old white female experienced chest pain and collapsed while skating. CPR was initiated at the scene and she was resuscitated at the local hospital. Large doses of vasopressors were required to support her blood pressure. An echocardiogram was obtained and demonstrated very poor function possibly consistent with a dilated cardiomyopathy. She was transferred to our institution for bridge to transplantation where she was placed on VA ECMO through the right neck. Her hemodynamics improved and her acidosis resolved, however, by 24 hours she demonstrated no neurologic function. A cerebral blood flow study was obtained and after demonstrating no flow, she was declared brain dead. After consulting with the medical examiner, the family was approached and consented to organ donation.

RESULTS: After appropriate declaration and consent, both patients were maintained on ECMO, stabilized, and transported to the operating room for multiorgan harvest. The liver from the first donor as well as the liver, pancreas and two kidneys from the second donor were all transplanted successfully. All recipients were reported as doing well. While neither donor had usable lungs, the heart and kidneys from the first donor could not be placed in time, partly because of refusals due to misinformation and a poor understanding of ECMO support.

CONCLUSION: Organ donation on ECMO is not only feasible but can be very successful from donors with isolated cardiopulmonary failure who are not septic and who have no other organ dysfunction while supported on ECMO. Continued education is needed to make the most of potential organ donation from these patients.

OF-01-016

HUMAN PERIPHERAL BLOOD EOSINOPHILS EXPRESS STEM CELL FACTOR

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Stem cell factor (SCF) or c-Kit ligand is a cytokine associated with the differentiation, survival, and activation of mast cells. Eosinophils have pleiotropic functions in several diseases and, together with mast cells, are key cells in allergy. Mast cell-eosinophil interactions can take place during the late and chronic phases of allergy. It was, therefore, investigated whether eosinophils can produce SCF and consequently influence mast cells. Human peripheral blood eosinophils variably expressed mRNA for the soluble and uncleaved forms of SCF (reverse transcription-polymerase chain reaction) and produced the 18.5-kd protein backbone of SCF (Western blot analysis). After overnight incubation in medium, eosinophils also produced SCF of higher molecular weight (42-45 kd) that might represent its glycosylated forms. Eosinophils expressed cytoplasmic SCF that colocalized with major basic protein (confocal laser microscopy). Freshly isolated eosinophils contained 8.9 ± 1.7 pg SCF/10^6 (mean ± SEM; enzyme-linked immunosorbent assay). Although overnight incubation of the eosinophils in either culture medium or in phorbol 12-myristate 13-acetate-calcium ionophore did not cause the secretion of SCF, the addition of chymase induced SCF release. In summary, it was demonstrated that human peripheral blood eosinophils are a source of SCF. These results may contribute to a better understanding of the interactions between eosinophils and mast cells in allergic inflammation.

OF-01-044

PATIENTS WITH MENTAL ILLNESS AND SMOKING CESSATION

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Nicotine Treatment Center, Indiana University

Background: This study was performed to determine the relationship between mental illness and smoking cessation and to describe the smoking-related characteristics of mentally ill patients enrolled in a university-based tobacco treatment program. The reasons for mentally ill patients smoking are multiple. Cessation techniques offer innovative strategies to assist quitting. Resent research has demonstrated that persons with mental illness are about twice as likely to smoke as other individuals. Methodology: This study utilized a descriptive design consisting of a convenience sample of seventy adult patients enrolled at a local cessation program in central Indiana. Patients included meet the criteria for a mental illness as defined by a diagnosis of bipolar, schizophrenia, depression, or a history of alcohol or drug abuse. Data were collected by extraction from the medical records including the participant's gender, age, medical history, smoking history, history of drug/alcohol use, the stage of quitting status, the Zung score, Fagerstrom test, and the Horn score. 3 and 6 month quit ratios were also determined. Results: The average age of initial smoking was 19.5 years for 39.9 pack years with 81.4% smoking non-menthol cigarettes. The average number of quit attempts was 4.1 with 91% of patients smoking filtered cigarettes. 55.7% of patients were in the readiness stage with a Fagerstrom score of 6.9 indicating addiction level. Zung scores noted mild depression overall. The Horn test indicated that tension reduction (12.6), relaxation (11.5) and craving (12.2) were the major factors to why these patients smoked. Pre-treatment CO level was 42.7 PPM and post-treatment was 22.6 PPM for the patient population in this study. The 3-month quit rate was 45.7% with the 6 month quit rate at 44.3%. Conclusion: Patients enrolled that are classified as mentally ill have less than a 50% quit rate at 3 or 6 months. These patients have indicted a desire to quit but face many difficulties during the treatment process. Patients' smoking-related characteristics and mental illness histories might have important implications for treatment design and success.

OF-01-071

THE USE OF INHALED PROSTACYCLIN FOR SELECTIVE REDUCTION OF PULMONARY ARTERY PRESSURES: PILOT DATA

Brian K. Walsh, BS, RRT; Allan Doctor, MD; Patricia Ann Doorley, MS, RRT; Stewart Lowson, MD; University of Virginia Health System; Charlottesville, Virginia.

Background Following the FDA's approval for the use of Inhaled Nitric Oxide (INO) in the neonate, the cost for the daily administration of INO was set by INO Therapeutics at $3000 per day. The cost of administration of this therapeutic agent has forced many clinicians to seriously consider both the indications for administering INO and the use of possible alternative, and less expensive, agents to selectively decrease pulmonary artery pressures (PAP). We have undertaken a clinical study to explore the use of inhaled prostacyclin as an alternative to INO in the management of children and adults with acute pulmonary hypertension complicating their clinical course.
Methods Inhaled prostacyclin was administered to five patients with elevated pulmonary artery pressures either (1) during pre-operative catheterization to determine operative risk and potential use as a post-surgical intervention or (2) following the operative procedure to improve right heart function and cardiac index. The inhaled prostacyclin was administered through the inspiratory limb of the ventilator circuit via continuous nebulization, using a MiniHeart® Nebulizer (Westmed, INC.) with the flow rate set at 2 Lpm and a Protégé 3010 Syringe Infusion Pump® (Medex) set at an infusion rate of 8 ml/hr when needed. The inhaled prostacylin dose was initiated at 50 ng/kg/min and then weaned as tolerated. Prior to, and during drug delivery, hemodynamic and respiratory variables were recorded and blood was drawn for ABG analysis and platelet aggregation studies.

Results

Age	Diagnosis/Procedure	Use of Inhaled Prostacylin	Mean PAP (% △)
5 mo	Pulmonary Stenosis/Cardiac Cath	Cardiac Cath	↓ 17
25 yo	Tetralogy of Fallot and Pulmonary Atresia/Cardiac Cath	Cardiac Cath	↓ 7
3 yo	VSD patch leak/Repair	Pre- and Post Op	↓ 19
63 yo	Severe MR/MV and AV replacement	Peri- and Post Op	↓ 40 - 50
35 yo	Rheumatic Mitral Stenosis/MV replacement	Peri- and Post Op	↓ 31

Conclusion The average daily cost for the administration of 50 ng/kg/min of inhaled prostacylin to a 70 kg adult is approximately $215. Therefore, inhaled prostacyclin bears further study as a selective pulmonary vasodilator and cost effective therapeutic agent for the acute management of elevated pulmonary artery pressures. OF-01-088

ABI VEST AIRWAY CLEARANCE SYSTEM USED DURING BILATERAL THERAPEUTIC WHOLE LUNG LAVAGE FOR THE TREATMENT OF PULMONARY ALVEOLAR PROTEINOSIS Davis, J., RRT, Popovich, M., MD
The Cleveland Clinic Foundation, Cleveland, Ohio.

BACKGROUND: Pulmonary alveolar proteinosis (PAP) is a rare disorder in which deposition of lipoproteinaceous material leads to progressive respiratory distress. Bilateral therapeutic whole lung lavage (BTWLL), which involves installation of large volumes of normal saline into the lung facilitated by double lumen endotracheal intubation, one lung ventilation, and general anesthesia, has been an accepted treatment for symptomatic relief of patients with PAP. During BTWLL, manual or hand-held pneumatic percussion to the chest wall is conventionally applied to assist in mobilization of the saline and removal of the proteinaceous sediment. We theorized that the ABI Vest Airway Clearance System, a novel total chest wall oscillation technique, might help improve efficacy of BTWLL. METHOD: A 43 year-old male presented to our institution for BTWLL. Prior to induction of anesthesia, he was fitted with the ABI Vest and educated about the rationale of total chest wall oscillation. BTWLL was performed serially via a #39 left endobronchial tube with 15 liters of warmed saline solution per lung, lavaged in 0.5-1 liter aliquots. Throughout the procedure the ABI Vest was inflated and oscillated the chest wall in 15-minute increments with 5-minute pauses. Oscillation was continued after the procedure in the PACU. The patient was allowed to recover for 2 hours, then was extubated. He was weaned to nasal oxygen and transferred to a regular nursiog hospital room within 5 hours post-procedure. DISCUSSION: The ABI Vest Airway Clearance System permitted more efficient percussion as compared to the standard manual or pneumatic hand-held technique. Total chest wall oscillation helped to uniformly mobilize saline and proteinaceous sediment whereas the manual method or use of a pneumatic hand-held device can only apply percussion to a localized area. Because the ABI Vest also provided posterior oscillation, the patient did not have to be subjected to the inherent risks of repositioning that would have been necessary to administer conventional percussion. In addition, the ABI Vest considerably reduced the intensive attention to manual percussion by the respiratory therapist, while providing improved overall chest wall oscillation. CONCLUSION: The ABI Vest Airway Clearance System is a viable alternative to manual or pneumatic chest percussion during BTWLL in the treatment of PAP.

OF-01-101

Concept of Operations For International Space Station Next-Generation Mechanical Ventilator

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Background:
When the space shuttle is not docked, use of the Soyuz transport/escape vehicle for medical deorbit to earth from the International Space Station (ISS) requires a change in philosophy for medical emergencies from one of stabilize and transport, to stabilize and manage. The current Autovent 2000 ventilator (Allied Health Products, Inc., St Louis, MO) provides adjustment of tidal volume and rate in control mode with additional breaths via a demand regulator. This ventilator is not designed nor intended for extended management (24-48 hours). The projects goals were to identify requirements for a next-generation ventilator that could operate on the ISS, Soyuz and Shuttle, and determine if commercial-off-the-shelf products could be used

Method:
A trade study was conducted of the transport ventilator market, 14 units were identified and evaluated based on information provided by the manufacturers. Categorical ratings were assigned for clinical capability, resource and operational use. Parallel efforts determined ISS resource capability, communications infrastructure, space medical requirements, and evaluated the applicability of closed-loop control systems.

Results:
Functional requirements for the next ISS ventilator included: A/C, SIMV, CPAP, PS, noninvasive ventilation, monitoring ($EtCO_2$, SpO_2, Vt, VE, VO_2, VCO_2, PIP, PEEP, R, C), wireless operation, closed-loop control, simple user interface, remote control and monitoring via industry standard device and network communication protocols, and support hyperbaric operations. The Eagle 754M (Impact Instrumentation Inc., West Caldwell, NJ) was identified as having many of the desired features.

Experience:
There have been smoke and toxic gas inhalation injuries during space operations however, none have required a ventilator. The evaluation team is a unique combination of engineers, physicians, respiratory therapists and researchers. Their experience encompasses many years of operational space medicine, biomedical engineering and clinical medicine.

Conclusion:
Decreases in FRC and RV seen in microgravity may lead to premature airway closure, while improvements in V/Q and diffusion capacity may reduce the incidence of hypoxemia associated with cardiopulmonary conditions. Given the uncertainties, the next generation ventilator will need to support the patient for an extended period and be administered by a non-clinician on orbit. Such a unit must allow monitoring and control by remote physicians. Additional work is required to develop remote digital monitoring and control as well as autonomous modes of operation. This work was supported under contract to NASA, NAS9-97005. OF-01-106

NOSOCOMIAL RESPIRATORY SYNCYTIAL VIRUS INFECTION IN AN ADULT RENAL TRANSPLANT PATIENT

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Introduction: Respiratory syncytial virus (RSV) is an important cause of severe lower respiratory tract infection in immunocompromised hosts. This report describes an unexpected case of nosocomial RSV pneumonia after kidney transplantation..
Case presentation: A 58 year old male who was discharged five days after receiving a cadaver renal allograft presented the following day with dyspnea and productive cough. The immunosuppressive therapy consisted of Cyclosporine-microemulsion, prednisone and mycophenolate mocfetil. The patient was on prophylaxis with TMP-SMX and acyclovir. On physical examination, the patient was in mild respiratory distress at rest, blood pressure 134/72mmHg, pulse of 72 per minute and temperature of 98.0F. Auscultation of his lungs revealed bilateral diffuse expiratory wheezes and crakles on the left side. Pulse oximeter reading was 92% while he breathed supplemental O2 at 2 l/min via nasal prongs. Initial chest radiograph showed a new patchy left upper lobe infiltrate. The serum sodium was 124 mEq/L, potassium 4.8mEq/L, chloride 93mE/L, carbon dioxide 25mEq/L, nitrogen urea 62mg/dL and creatinine 3.8mg/dl. White blood cell count was 10,600/cc and hemoglobin 10.4g/dL. Initial empiric antibiotic therapy consisted of levofloxacin and ceftriaxone. The patient deteriorated, and a repeat chest radiograph showed worsening of the left upper lobe infiltrate. The antibiotic coverage was changed to fluconazole, ceftazidime and vamcomycin, and the patient was transferred to the intensive care unit. A bronchoalveolar lavage (BAL) initially yielded no organisms. RSV was isolated from the BAL fluid by immunofluoresence at 48 hours. Therapy with nebulized ribiravin was considered but not administered because the patient was clinically improving. The patient was subsequently discharged and at 6-weeks follow up a chest radiograph showed resolution of the infiltrate and his renal graft was functioning. Retrospective investigation revealed that at least three heath care workers directly involved in the care of the patient during the initial hospitalization had experienced non-specific upper respiratory symptoms. No other contact was identified on the transplant ward.
Discussion: In a patient receiving immunosuppresive therapy, the onset of dyspnea suggests a pulmonary infection. The incidence of bacterial pneumonia in the first three months after renal transplantation has been described to be in the range of 1 to 2%. Nosocomial pneumonia was considered hence the sequence of antimicrobial agents. The time of hospitalization of our patient corresponded with an upward trend in the percent of antigen detection and isolation of RSV in the Southern United Sates. Outbreaks of RSV occur during late fall, winter or spring. Rapid antigen detection methods for diagnosing RSV are more sensitive in samples from the lower airways. In our case a rapid test was not requested because the possibility of RSV was not entertained. Nosocomial transmission of RSV usually starts after the inadvertent introduction of the virus by a family member or a health worker, as was suspected in our case. The transmission of RSV can occur by droplets, at a distance of less than 0.9m, or by self-inoculation of the respiratory tract after acquiring the virus from a fomite. The role of precautions including hand-washing, and the use of gloves and gowns is recommended. Although response to aerosolized ribavirin has been described, supportive care is the mainstay of treatment as provided in the present case.

OF-01-107

Venturi Mask System to Support Space Medical Operations

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Background:
When the space shuttle is not docked, use of the Soyuz transport/escape vehicle for medical deorbit to earth from the International Space Station (ISS) requires a change in philosophy for medical emergencies from one of stabilize and transport, to stabilize and manage. The Soyuz is not capable of transporting an intubated/ventilated crew member therefore, on-orbit weaning and extubation along with a mechanism for delivering variable FIO_2 is required. Shuttle (STS) and International Space Station (ISS) medical kits do not contain a method for delivering adjustable concentrations of O_2 during medical contingencies. A standard air/O_2 blender is not feasible as the ISS has only compressed O_2 and N_2. In addition, there is no method or supporting equipment (weaning modes of ventilation, spirometer, etc) for weaning from mechanical ventilation. This study sought to identify a Venturi mask system that could be used on STS and ISS for supplemental O_2 and weaning via a T-Piece.

Method
A trade study of Venturi mask vendors was done, 8 vendors were identified, 5 of which, responded and supplied samples. All units were tested for delivered FIO_2 using a standard back-pressure compensated flowmeter (Ohmeda Model AHE, Columbia, MD) and the ISS flowmeter with a calibrated O_2 analyzer (Servomex Model 571, Sussex, England). Units were evaluated for ease of use, number of parts, range of concentrations and visibility of the markings.

Results:
All of the units delivered O_2 accurately at the set concentration (max FIO_2 difference ±0.02) using the standard and ISS flowmeters and all supported use with a T-piece. The Salter model 8150 was found to have the fewest parts and was one of the easiest to read and therefore would support use by a non-physician crew medical officer in flight.

Conclusion:
A Venturi system could be used to support low-dose O_2 administration and used with a T-piece for spontaneous breathing trials. Its use would enhance current care capability, avoid inefficient O_2 use and minimize the risk of O_2 toxicity and fire. Stonehill and Peoples (1982) demonstrated that Venturi devices maintain the set inspired O_2 fraction over a range from sea level to 10,000 feet altitude the minimum nominal cabin pressure for STS and ISS. While FIO_2 will need to be adjusted to maintain an acceptable PIO_2 at altitude, their work demonstrates predictable performance of Venturi devices at altitude.
This work was supported under contract to NASA, NAS9-97005. OF-01-108

Relationship between expression of heme oxygenase-1 mRNA and pulmonary hypertention induced by hypoxic hypercapnia

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AIM: To study the effect of chronic hypoxic hypercapnia on expression of heme oxygenase-1(HO-1). **METHODS:** Thirty-six Sprague-Dawley rats were randomly divided into three groups;normal control group(A),hypoxic hypercapnic group(B), hypoxic hypercapnia+hemin group(C). HO-1 was observed in arterioles from rats by the technique of immunohistochemistry,HO-1 mRNA was observed in arterioles from rats by the technique of in situ hybridization.The average value of integral light density(LD) of HO-1 and HO-1 mRNA in pulmonary arterioles were detected by an image analysor and the relative content of HO-1 and HO-1 mRNA were calculated. **RESULTS:** mPAP and weight ratio of right ventricle(RV) to left ventricle plus septum(LV+S) were significantly higher in rats of B group than those of A group($p<0.01$) and they were much lower in rats of C group than those of B group($p<0.01$).Differences of mCAP were not significant in three groups($p>0.05$); Blood CO concentration was significantly higher in rats of B group than that of A group($p<0.01$), blood CO concentration was significantly higher in rats of C group than that of B group($p<0.01$); Light microscopy showed that WA/TA(vessel wall area/total area) SMC (the density of medial smooth muscle cell) and PAMT(the thickness of medial smooth cell layer) were significantly higher in rats of B group than those of A group($p<0.01$),WA/TA SMC and PAMT were significantly lower in rats of C group than those of B group($p<0.01$); Electron microscopy showed proliferation of medial smooth muscle cells and collageous fibers of pulmonary arterioles in rats of B group, and hemin could reverse the changes mentioned above; Immunohistochemstry showed that LD of HO-1 in pulmonary arterioles was significantly higher in rats of B group than that of A group($p<0.01$), HO-1 in pulmonary arterioles was significantly lower in rats of C group than that of B group($p<0.01$); Hybridization in situ showed that LD of HO-1 mRNA in pulmonary arterioles was significantly higher in rats of B group than that of A group($p<0.01$), HO-1 mRNA in pulmonary arterioles was significantly lower in rats of C group than that of B group($p<0.01$).**CONCLUSION:** Expression of HO-1 mRNA and HO-1 in pulmonary arterioles can be enhanced by hypoxic hypercapnia; hemin can partly inhibit pulmonary hypertension and pulmonary vessel remodeling by enhancing the Expression of HO-1 mRNA and HO-1.
[MeSH] Carbon monoxide; Heme oxygenase; Anoxia; Hypercapnia; Hypertension,pulmonary; Gene OF-01-109

INTRAVASCULAR PRESSURE WIRE TRASDUCER SYSTEM MAINTAINS ACCURACY OVER MANY DAYS, AN IN VITRO EXPERIMENT

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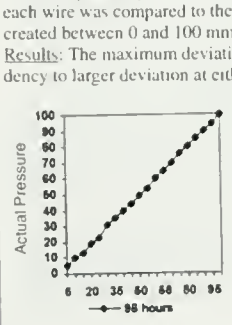
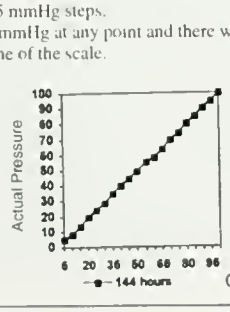
Introduction: It is desirable to be able to monitor pulmonary artery and cardiac chamber pressures following complex congenital heart defect repairs in small infants. Conventional monitoring devices are large, have embolic risk, and require large fluid infusions. Also, removal of these devices is occasionally complicated by significant hemorrhage. Solid state wire-mounted micro transducer devices have been available for short term use during catheterization (RADI Pressure Wire® XT, RADI Medical Systems, Reading, MA) and have a proven accuracy. Because the transducer is intravascular, however, re-zeroing after the initiation of monitoring is not possible. The possibility of longer-term use following cardiac surgery led us to evaluate their precision over time (drift) in an in vitro test system.
Methods: A piece of Tygon tubing (0.25 inch internal diameter) approximately 12 inches long was sealed at end with a three way stop-cock. From one end, a conventional saline filled transducer (Transpac® Abbott Critical Care Systems, Chicago, Illinois) was attached to the stopcock and Zeroed to atmosperic pressure. From the other a RADI Pressure Wire® was attached to the free port of the stopcock and floated 5 inches into the tubing following zeroing to atmospheric pressure and calibration with it's monitor unit. A 60 cc syringe was used to fill the test system with normal saline and to pressurize it between 25 and 35 torr. The pressure was maintained at this level for 96 hours in one experiment and 144 hours in a second experiment with a second wire. Temperature was not controlled and remained passively between 20 and 23° C. Following the experimental period, each wire was compared to the standard transducer. A calibration curve was created between 0 and 100 mmHg with 5 mmHg steps.
Results: The maximum deviation was 3 mmHg at any point and there was no tendency to larger deviation at either extreme of the scale.





OF-01-117

AGREEMENT AND REPRODUCIBILITY OF A POINT-OF-CARE SYSTEM FOR BLOOD GASES ANALYSIS (i-STAT)

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Background: The introduction of a Point-of-care (POC) system for blood gases analysis (i-STAT, i-STAT Corporation) to our clinical practice prompted the questions of agreement with our previous system (IL Synthesis, Instrumentation Laboratory) and the reproducibility of the new system. Both systems use direct potentiometry for the calculation of PCO2 and pH and the pO2 is measured amperometrically.

Method: Two groups of arterial blood samples were obtained and analyzed for pH, pCO2 and PO2. The first group (n=75) was analyzed by both systems. The second group (n=50) was analyzed by the POC system twice. The bias, or mean difference and the limits of agreement for the two groups were calculated by the statistical method described by Bland and Altman for comparing methods of measurement. The 95% Confidence Intervals (CI) of the limits of agreement of the groups were assessed to determinate the agreement between both systems and the reproducibility of the POC system in the clinical practice.

Results:

	Group 1: Agreement between I-stat and IL Synthesis				
	Bias	**LLA**	**95%CI**	**ULA**	**95%CI**
pH	-0.01	-0.05	-0.045,-0.055	0.03	0.025,0.035
pCO2 (kPa)	-0.09	-0.69	-0.59,-0.79	0.5	0.4,0.6
pO2 (kPa)	0.29	-1.74	-1.41,-2.08	2.33	2.00,2.67
	Group 2: Reproducibility of I-stat				
	Bias	**LLA**	**95%CI**	**ULA**	**95%CI**
pH	0.001	-0.02	-0.017,-0.023	0.02	0.017,0.023
pCO2 (kPa)	0.03	-0.41	-0.32,-0.49	0.46	0.38,0.55
pO2 (kPa)	0.09	-1.1	-0.86,-1.37	1.27	1.03,1.51

LLA: Lower Limit of Agreement **ULA:** Upper Limit of Agreement

Experience: The POC system has been in service at our institution for 26 months.

Conclusion: In our clinical practice both systems can be used interchangeable. The bias found between both systems can be partially explained by the reproducibility of the i-STAT. We recommend the interchangeable use of the i-STAT and the IL Synthesis when the clinician determines that the limits of agreement of the bias will not significantly interfere with the medical care of the patient. OF-01-119

WHAT IS THE POTENTIAL FOR SUDDEN CARDIAC DEATH DUE TO LONG Q-T SYNDROME IN INTERCOLLEGIATE ATHLETES?

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Research Question: What is the prevalence of Long Q-T Syndrome in athletes who play intercollegiate sports? Is screening necessary? Can a simple six-lead EKG be used to identify persons at risk? **Methods & Materials:** Athletic trainers and coaches recruited volunteers from male and female inter-collegiate athletes who play basketball, soccer and track. Volunteers were screened and exclusion criteria included a diagnosed history of heart disease, a family history of EKG abnormalities, and the use of medication that could prolong the Q-T interval. Twelve athletes (5 male and 7 female) participated. Informed, signed consent was obtained prior to any testing. A resting six lead EKG (KoKo Rhythm, Pulmonary Data Services, Louisville, CO), blood pressure hy spygomanometer and pulse was taken prior to a workout. The KoKo Rhythm software read and corrected the Q-T interval for heart rate. **Results:** Twelve intercollegiate athletes met the inclusion criteria and signed informed consent. The average age was 19 y/o (range 18 –21) with an average height of 67.4 inches (the average male was 70 inches while the average female was 66 inches) and weight of 150 lbs. (the average male was 32 lbs. heavier than his female counterpart). There were no significant diferences in tympanic body temperature (96.3°F), blood pressure (116/72 male vs. 116/69.4 female) or resting heart rate (71.2 male vs. 72.7 female) among the participants. Corrected QT intervals (QTc) for heart rate averaged 404 msec with a mean QTc of 414 (range 352 – 468 msec). QTc for male athletes averaged 395.2 msec and a mean QTc of 408 msec. with a range of QTc of 352 to 414 msec (25.56 SD). Female intercollegiate athletes had an average QTc of 410.7 msec and a mean QTc of 404 msec with a range of 386 to 468 msec (27.20 SD). Of the athletes studied four of the twelve (33.33%)had Q-T intervals above the upper limits of normal. One male had a Q-T interval greater than the upper limit of normal 404 msec for the heart rate of 67 (410 msec). Meanwhile three female athletes were identified as having QTc's of 386 msec 399 msec, and 468 msec (Upper Limit of Normal for these females were: 372 msec, 423, and 464 msec respectively). There were no significant differences in age, blood pressure or heart rate among the athletes.

Conclusinns: Although our data suggests that a potentially significant number of intercollegiate athletes may have an increased, i.e. above the upper limit of normal, Q – T interval more research is required.

OF-01-146

A PROSPECTIVE, RANDOMIZED TRIAL COMPARING HYPOXIA TO HYPERCARBIA IN PRE-OPERATIVE PATIENTS WITH HYPOPLASTIC LEFT HEART SYNDROME.

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Background: An important component in the pre-operative management of patients with hypoplastic left heart syndrome (HLHS) is maintaining a balance between pulmonary vascular resistance (PVR) and systemic vascular resistance. In some cases it is necessary to increase PVR in order to improve systemic blood flow. This may be accomplished via induced hypoxic gas mixture with nitrogen to decrease the FiO_2 to 15%-20%, or induced hypercarbia with inspired carbon dioxide of 7 torr-50 torr. We compared oxygen delivery to pre-op patients with HLHS under the conditions of 17% FiO_2 and 20 torr carbon dioxide.[1]

Methods: This is a prospective, randomized trial comparing hypoxia (17% FiO_2) to hypercarbia (20 torr CO_2) in pre-operative patients with the diagnosis of HLHS. The inclusion criteria for this study were pre-operative HLHS, endotracheal intubation, no pulmonary pathology by CXR, central venous catheter with tip in SVC and IRB approved consent from parents.
In this crossover design, the patients were mechanically ventilated on room air to normocapnia at baseline and were randomized to receive either 17% FiO_2 or 20 torr CO_2 first. All patients received both conditions. Each condition (hypoxia/hypercarbia) was maintained for 10 minutes with a 20 minute period in between to allow for return to baseline. Data collected at each condition included arterial and SVC blood gas with co-ox, heart rate, mean arterial pressure, SpO_2 and exhaled minute ventilation. The CO_2 was delivered at the outport of the ventilator and measured pre-humidifier via Nellcor Ultracap. The nitrogen was delivered via the oxygen high pressure hose on the ventilator and FiO_2 was analyzed pre-humidifier via Ceramatec oxygen analyzer. The patients were ventilated via the Servo 300 venulator in the PRVC mode.

Results :

	Baseline	Hypoxia	p Value	Baseline	Hypercarbia	p Value
pH	7.44 ± .02	7.46 ± .02	.012	7.42 ± .02	7.32 ± 01	.002
PO_2	50.3 ± 1.9	42.2 ± 1.8	<.0001	49.6 ± 1.6	50.8 ± 1.9	NS
pCO_2	37.5 ± 1.8	35.7 ± 2	NS	39.4 ± 1.6	53.7 ± 1.6	.002
SpO_2	93.2 ± 1 5	89.8 ± 2.8	.004	92 ± 1.3	90.2 ± 1.8	.04
Heart rate	160 ± 6	153 ± 4	NS	150 ± 5	149 ± 4	NS
MAP	45.3 ± 2.5	44.2 ± 2.4	NS	42.8 ± 3.7	50.7 ± 2.8	NS
Qp:Qs	3.4 ± .5	2.6 ± .5	.056	3.1 ± .5	2.2 ± .6	.026
A-VO_2	28.3 ± 3.2	28.8 ± 3.8	NS	28.5 ± 3.6	19.9 ± 3.8	.005

Cnnclusinn

For pre-operative patients with HLHS who are anesthetized, paralyzed, and fully supported on mechanical ventilation, hypoxia decreased oxygen delivery while hypercarbia increased oxygen delivery

1. Tabbutt S, et al. Impact of Inspired Gas Mixtures on Pre-Operative Infants with Hypoplastic Left Heart Syndrome During Controlled Ventilation. Circulation 2000; 102(suppl II) II-469

OF-01-225

BRONCHOSCOPIC SURFACTANT LAVAGE IN SEVERE ARDS: CASE REPORT

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Introduction: Replacement of diminished surfactant activity in the lungs has been proposed to be of benefit in ARDS. We present a case in which bronchoscopic surfactant lung lavage caused dramatic temporal improvements in gas exchange. Case Summary: A 40 yr old woman had group A streptococcal pneumonia, bacteremia, and profound septic shock. She was intubated and within hours had diffuse bilateral infiltrates, reduced compliance, and hypoxemia consistent with ARDS. CVVHD was begun for anuric renal failure. High dose vasopressors, paralysis, FiO2 1.0, and PC-IRV were required. Despite this, the patient remained severely hypoxemic with O2 saturations in the 70s. Inhaled NO was begun with some improvement in oxygenation. Prone positioning initially caused marginal improvement in PaO2 but soon became ineffective. By day 4, the patient was on FiO2 varying from .80 to 1.0, remained hemodynamically unstable, and had distal extremity gangrene. Bronchoscopic lavage with commercially available surfactant was considered as a possible salvage. After consent was obtained, a quantity of beractant (Survanta®), a bovine surfactant, was acquired and divided into 15 syringes, each containing 16 ml of surfactant 25 mg/ml (total dose 125 mg/kg). Bedside bronchoscopy was then performed. The scope was wedged into a segment (in some cases 2 segments per syringe) and surfactant instilled. After 10-20 sec the area was suctioned; each segment was treated similarly. The procedure took 30 min. No oxygen desaturation occurred. Immediate improvement in oxygenation was seen (Table), and by 12 hours later the FiO2 could be lowered to .50. Rapid hemodynamic and gas exchange improvement followed over 48 h. The patient eventually required extremity amputations, but otherwise fully recovered and was extubated 18 days following surfactant.

Time	Pre-Rx	30 min	6 h	12 h	24 h	48 h
PaO2	68	85	77	81	103	69
FiO2	.95	.90	.70	.50	.50	.40
PEEP	15	16	16	16	16	15
I:E ratio	2:1	2:1	2:1	2:1	1.5:1	1:1.5
PaO2//FiO2	72	94	110	162	206	173

Discussion: Large-scale studies of aerosol and bolus delivery of surfactant have thus far failed to show convincing benefit in ARDS. Two small series of bronchoscopic lavage with surfactant did demonstrate physiologic improvements. The present case adds to this literature and suggests that at least some ARDS patients may benefit from bronchoscopic instillation of effective formulations of surfactant. Controlled clinical trials of this method are urgently needed.OF-01-208

ADEQUACY OF NON-BRONCHOSCOPIC, PROTECTED, BRONCHOALVEOLAR LAVAGE (NB-PAL) SPECIMENS OBTAINED BY RESPIRATORY CARE PRACTITIONERS (RCP) FOR DIAGNOSING VENTILATOR ASSOCIATED PNEUMONIA (VAP).

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BACKGROUND: Diagnosis of VAP is difficult and may be aided by obtaining NB-PAL specimens. Over 20% of non-protected, blindly obtained BAL specimens are inadequate.(Spencer et al, AJRCCM 98:A313) Potential advantages of NB-PAL are. collection of specimens by bedside staff, specimen collection prior to initiating antibiotic therapy, reduction in # of inadequate or contaminated specimens, and more appropriate selection of initial empiric antibiotic therapy. We report our experience using NB-PAL specimens obtained by RCPs for the diagnosis of VAP. **METHODS:** Following an initial one hour in-service, RCP's began collecting NB-PAL specimens in ICU pts with clinical signs of VAP (WBC > 10k, T > 38.5 C, infiltrate on CXR, and purulent sputum). Specimens were obtained using an 8 French, plugged, telescoping catheter (CombiCath™, PlastiMed) utilizing a lavage volume of 20 ml. Specimens were considered adequate if > 1 ml was retrieved and no epithelial cells were observed on initial direct observation. We recorded aspirated lavage volume, gram stain results, # of inadequate specimens, final culture results, appropriateness of initial empiric antibiotic therapy, and any complications (SpO_2 < 92%, 10% Δ in HR or BP sustained > 5 min, bleeding, pneumothorax, etc.) observed during the NB-PAL procedure. **RESULTS:** One hundred and five pts were studied during a six-month period ending 30-Apr-01. Lavage volume aspirated during the NB-PAL procedure was 2.1 ± 0.6 ml. Four (3.8%) of the NB-PAL specimens were inadequate due to presence of epithelial cells and all specimens were > 1 ml. Of the remaining 101 specimens, 34 were positive for VAP (organisms> 10^4 cfu/ml on final culture) and 35 negative for VAP (no growth on final culture). The remaining 32 (31.7%) specimens were indeterminate (10^1-10^3 cfu/ml on final culture). Gram stain results were correlated with the final culture result in 90 cases, partially correlated in 3 cases, and not correlated in 8 cases. Initial empiric antibiotic therapy guided by the Gram stain was appropriate in 97 cases. No episodes of hypoxemia were reported, as pts were ventilated with FiO_2 of 1.0 prior to and during the procedure. Minor bleeding was reported in 9 patients and significant hemodynamic changes were reported in 4 cases and all were resolved without clinical sequelae. Duration of the procedure was < 10 minutes in all cases. **CONCLUSION:** NB-PAL specimen collection by RCPs can be performed safely and quickly. The NB-PAL procedure is well tolerated, and yields an acceptable specimen for microbiological analysis in over 95% of cases. Use of a polyethylene glycol plug at the tip of the catheter may reduce the number of inadequate or contaminated specimens. Grams stain results from NB-PAL specimens strongly correlate with final culture result and may be used to guide initial empiric antibiotic therapy. NB-PAL specimens are useful diagnostic tools that aid in the diagnosis of VAP in over two-thirds of our Surgical ICU pts with suspected VAP.

OF-01-248

ANALYSIS OF THE TIMES OF VISIT TO THE ED OF CHF PATIENTS WITH SOB AS THE CHIEF COMPLAINT. Andrea A. Adedunsan, BS, CRT, Lisa M. Hicks, BS, CRT, David C. Shelledy, PhD, RRT. The University of Texas Health Science Center at San Antonio

Abstract

Background: In patients with chronic congestive heart failure (CHF), shortness of breath (SOB) is a common symptom. We sought to determine what times of the day CHF patients visited the emergency department (ED) the most within a time frame of 24 months.

Method: Following an Institutional Review Board approved protocol, we performed a retrospective analysis of records of 222 CHF patients who presented to the ED of a 492 bed University affiliated hospital, for a period of 24 consecutive months. Specific records were evaluated to determine the time of presentation to the ED with SOB as a chief complaint. All CHF patients that visited the ED for SOB were analyzed with no age/gender limit to the data analyzed, men and women with age ranges from 29-90 years old were in the data analysis.

Results: Table 1 displays the number of CHF patients versus the time of day of admissions to the ED for each 24 hour period during the 24 month sample of records.

Admit Time	# of Patients	Shift
07:00 - 07:59	11	1st
08:00 - 08:59	3	
09:00 - 09:59	8	
10:00 -10:59	11	
11:00 - 11:59	14	
12:00 - 12:59	20	
13:00 - 13:59	7	
14:00 - 14:59	12	
15:00 - 15:59	15	
16:00 - 16:59	10	
17:00 - 17:59	8	
18:00 - 18:59	16	
19:00 - 19:59	9	
20:00 - 20:59	10	
21:00 - 21:59	5	
22:00 - 22:59	8	
23:00 - 23:59	10	
00:00 - 00:59	5	
01:00 - 01:59	8	
02:00 - 02:59	9	
03:00 - 01:59	8	
04:00 - 04:59	5	
05:00 - 05:59	3	
06:00 - 06:59	7	

Conclusions: The data suggests that there is an increase in ED visits by CHF patients with SOB between the 1100 and 1800 hours. There is a relatively low ED visits at the hours of sleep between 2100 and 0500 hours. Our data suggest, that nocturnal dyspnea may not be the primary reason why CHF patients visit the ED. We conclude from our sample that there were more CHF patient visits to the ED due to SOB between of 1100 and 1800 hours.

OF-01-259

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VENTILATOR-ASSOCIATED PNEUMONIA (VAP) EDUCATION INTERVENTION

Darnetta Clinkscale RRT; Jeanne Zack RN; Marin Kollef MD, Peggy Reed-Watts RRT; Lloyd Thompson RRT; Mary Finayev RRT, Donna Clayton RRT; Pulmonary and Critical Care Division, Respiratory Care Services and Infection Control, Washington University School of Medicine and Barnes-Jewish Hospital (BJH), St. Louis, Missouri.

Background: Ventilator-Associated Pneumonia (VAP) Education Intervention was undertaken at BJH to address VAP in our ICUs. The literature shows that VAP is the leading cause of death of hospital-acquired infections with mortality rates of 20-50%. The Centers for Disease Control and Prevention estimates that an episode of VAP adds 5.9 days to a patient's hospital stay. We hypothesized that comprehensive training of RT could reduce the rate of VAP, improve patient outcomes and reduce cost at our hospital.

Method: A multi disciplinary education module, "**WHAP VAP!"** was developed by the Infection Control department at BJH. The acronyms "**WHAP VAP!"** stands for **W**-wean the patient. **H**-hand washing. **A**-aspiration prevention precautions. **P**-prevent contamination. The education module consisted of staff inservices, a self-study booklet and pre/post tests for documenting competency. The educational content was supported by a series of fact sheets and a poster highlighting key points of the "**WHAP VAP!"** campaign. All RT (100%) staff and ICU nursing staff were offered the education module. Although nursing compliance varied unit by unit, 100% of the RT staff completed the module and testing.

Results: The "**WHAP VAP!"** intervention successfully decreased the VAP rate by 49% in the ICU's. The total number of VAP cases and excess length of hospitalization decreased by 47%. The cost of VAP prior to the intervention was $1,265,330 and after the intervention was $683,060. This 46% decrease in excess cost resulted in saving the hospital $582,270.

	Before the Intervention (1999 Q4, 2000 Q1 & Q2)	After the Intervention (2000 Q 3, Q4, & 2001 Q1	Percent of Decrease
Total # VAP	154	82	47%
VAP/1000 ventilator days	25.0	12.79	49%
Excess days of hospital length of stay	924	492	47%
Excess cost	$1,265,330.00	$683,060.00	46%

Experience: Our experience demonstrated (see table) that with 100% training and competency verification of RT staff, we could decrease the number of patients with VAP and the risk to this high risk ICU patient population.

Conclusions: "**WHAP VAP!"** was added to the orientation for all new RT staff and a mandatory biannual update with testing for 100% of all RT.

OF-01-260

COGNITIVE APPRAISAL, COPING RESPONSES AND QOL IN ASTHMATICS

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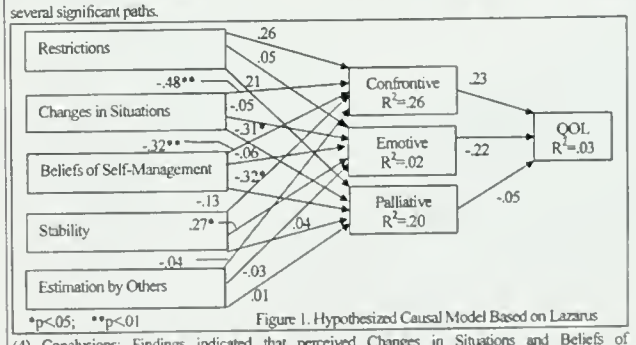
(1) Background: A causal model based on Lazarus' (1984) cognitively oriented theory of psychological stress and coping was tested in an asthmatic population to determine the effects of cognitive appraisal of stress, coping responses and QOL. Cognitive Appraisal of Stress (Restrictions, Changes in Situations, Beliefs of Self-Management, Stability, and Estimation by Others) was hypothesized to affect Coping Responses. Coping Responses (Confrontive Coping, Emotive Coping, and Palliative Coping) were hypothesized to directly affect QOL.

(2) Method: Data from 102 asthmatic outpatients from one respiratory facility were analyzed using path analysis. An informed consent letter that contained information concerning the voluntary nature of the study and the confidentiality of the responses and the questionnaire were given to potential subjects at their regular consultations. Cognitive Appraisal of Stress was measured by the Cognitive Appraisal of Stress for Respiratory Care (CASR) (Konishi, 2000). Coping Responses were measured by the Jalowiec Coping Scale (JCS) (Jalowiec, 1988). QOL was measured by the Cantril Life Satisfaction (CLS) (Cantril, 1965).

(3) Results: The path diagram of the model (Figure 1) with its respective path coefficients illustrates several significant paths.



*p<.05; **p<.01 Figure 1. Hypothesized Causal Model Based on Lazarus

(4) Conclusions: Findings indicated that perceived Changes in Situations and Beliefs of Self-Management were significantly and negatively related to Confrontive Coping and Palliative Coping, and perceived Stability was significantly and positively related to Emotive Coping.

OF-01-261

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APNEA MONITOR MANAGEMENT ALGORITHM AND DEDICATED STAFF REDUCE LENGTH OF MONITORING AND DECREASE COST OF CARE

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Background: Infant cardiorespiratory (apnea) monitoring has been used in the home management of high-risk infants (infants thought to be at risk for sudden death or rapid cardiorespiratory compromise) for nearly 3 decades. Despite its long tenure, there is no standardized care model for the planned discontinuation of monitors. The last nationally published consensus statement specific to this topic was printed in 1986. Technological advances in infant monitoring devices have lead to newer, very sophisticated monitors with full-disclosure memory systems, compliance tracking, and downloadable event waveforms. Historically, high-risk infants were monitored for extended periods (>6 mos. to 1 year) and caregiver history of symptom resolution the primary deciding factor for monitor discontinuation. High-risk infants are now commonly divided into two categories: *non-technology dependent-symptomatic infant* (idiopathic apnea of prematurity, apnea of infancy, etc.) and *technology dependent infant* (requires oxygen, tracheostomy, ventilation, etc.). It is the accepted standard of practice to monitor *technology dependent infants* until their technology needs are eliminated (i.e., weaned from oxygen). No such standard exists for non-technology dependent infants. Therefore, we developed a management algorithm based on current published information, the technological features of the Healthdyne 970 series infant monitor, and the state of Ohio Medicaid coverage rules.
Method: In mid-1997 we developed an apnea monitor management algorithm for non-technology dependent infants. It is structured around scheduled monthly home visits and the use of regular downloads to quantify the resolution of symptoms (prolonged apneas, bradycardias, etc.). From 1997-1999 we saw average monitoring periods decrease from ~7 months to 5 (4.64) months. Despite the presence of the algorithm, clinician workloads often prevented strict adherence to the protocol. In 2000 we assigned one full-time clinician to manage the infant monitor program. This included patient follow-up and physician communication. We used 1998 as our control period and 2000 as our study period. All *non-technology dependent infants* on monitors were included in the study group. All study patients were seen monthly and downloads were performed as per the protocol.
Results: The mean length of monitoring decreased from 4.64 months in the control group (n = 52) to 2.83 months in the study (n = 86), yielding a 39% reduction in mean monitoring time. Eighty-four percent (84%) of the patients in the study group had their monitors discontinued in <120 days, compared to 48% in the control. Although downloads increased by 13% in the study group, this was predicted considering that the download is the primary data used to confirm the absence of symptoms. The average 2-month reduction in monitor use reduced the cost of care in the study group by $500 per patient or approximately $43,000 annually (based on the Ohio Medicaid allowable of $250/mo.).
Conclusion: The use of an apnea monitor management algorithm, along with dedicated clinical staff, demonstrates a significant reduction in home apnea monitor lengths of utilization in *non-technology dependent* infant monitor patients. Additional study is needed to develop universally accepted home infant monitoring discontinuation practices.

OF-01-008

PATIENTS' UNDERSTANDING OF INCENTIVE SPIROMETRY

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BACKGROUND Incentive Spirometry (IS) is a procedure that is used to prevent lung collapse after a patient undergoes surgery. Minimizing patient complications through proper instruction on IS is the goal. **PURPOSE** This study was conducted to find out how well educated patients are on IS. **METHODS** This descriptive study included a convenience sample of 21 post-operative thoracic surgery patients at a large university hospital once they reached the general care floors. Patients were observed as they performed the procedure, following which we asked a series of questions relating to IS knowledge. Then the patients were asked open-ended questions about their education on IS. Patients also used a 5-point Likert scale to rate their overall perception of how well they were educated. The independent groups t-test ($p \leq .05$) was used to compare group means. **RESULTS** We found that 67% of the patients did not know the purpose of IS. Forty-eight percent of patients did not perform a slow breath while doing IS, and 62% did not perform a breath hold. Males scored significantly higher on IS knowledge with a mean score of 6.6, while females had a mean score of 4.5 out of 11. There was not a significant difference in scores based on age. When we asked their opinion on how well they were taught IS we found that 28% of the participants strongly agreed that they were well educated, 62% agreed, 5% were undecided, 5% disagreed, and none strongly disagreed. **CONCLUSIONS** In spite of the majority of patients agreeing that they had been educated well on IS, we found that they did not use IS correctly and had insufficient knowledge about the procedure. More research should be conducted to find out in which areas proper patient instruction is lacking.

OF-01-033

COMPARISON OF CLINICIAN ASSESSMENT OF HEMODYNAMIC STATUS WITH ACTUAL DATA OBTAINED THROUGH A MINIMALLY INVASIVE LITHIUM DILUTION METHOD

- Siddall, V.J., MS, RRT, CCRC, Gould, R.W., MD, Peruzzi, W.T., MD. Critical Care Medicine, Dept. of Anesthesiology, Northwestern Memorial Hospital and Northwestern University Medical School, Chicago, IL

Background: Advances in technology permit a variety of invasive, minimally invasive, and non-invasive monitoring options for clinicians to utilize in the care of ill patients. This poses a complex issue of determining what monitoring device should be used to provide accurate, timely information in the least invasive manner. A minimally invasive method of obtaining cardiac output and systemic vascular resistance through the use of lithium chloride has been developed (LiDCO, LTD. London, UK.). This system has been shown to be at least as accurate as thermodilution and avoids some of the potential risks with placement of a pulmonary artery catheter (1,2). In this study, we examined whether utilization of the Lithium Dilution Cardiac Output (LiDCO) system provided clinical information that changed the opinion of the clinicians regarding the hemodynamic status of patients and if this information altered treatment plans. **Methods:** Information was gathered as part of a clinical assessment of device utility and data were analyzed after IBR approval. Clinicians were asked to fill out a questionnaire at the bedside regarding their clinical assessment of the hemodynamic status of the patient. A LiDCO determination was then performed on the patient and the results were compared with the answers on the questionnaire. The clinicians were then asked if they were going to change the hemodynamic management of the patient based on the results of the LiDCO.
Results: Fifty-one assessments were made. Data were analyzed via chi-squared test with Yates correction. The data indicated that practitioners were unable to identify the underlying hemodynamic status based on clinical assessment alone. Practitioners were unable to distinguish between CI and SVRI as the contributor to hemodynamic instability. When presented with LiDCO information, therapy aimed at hemodynamic support was changed in a significant number (24.7%) of patients. **Conclusion:** This study demonstrates the difficulty of determining hemodynamic status of patients on the basis of clinical assessment alone. Additionally, the information provided by more advanced hemodynamic assessments altered therapy in a significant number of patients. The results suggest that LiDCO can offer rapid minimally invasive, and accurate, hemodynamic information that is not clinically evident and that can enhance development of focused treatment.

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OF-01-046

ELEVATED NOISE GENERATION BY CPAP DEVICES.

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Background: Sound of sufficient intensity and duration can affect the mood and concentration of hospitalized patients and health care workers. Studies have suggested that hospital noise and noise producing devices are a potential health hazard. Stand alone CPAP devices have this potential. The aim of this study is to investigate factors that set the noise level generated by 5 CPAP devices.
Method: In a clinical laboratory setting, the factors tested were: distance from the device (0.5 meter, 1.5 m), tubing type in use (corrugated, smooth), PEEP valve in use (5,10,15 cm H_2O), flow setting (maximum flow, flow = 80 L min^{-1}) and filter use (serving as a muffler on 2 devices only). Measurements of the noise levels of the devices were taken by an A-weighted sound meter (model 407703, Extech, Taiwan, CHN). Results were analyzed by ANOVA (super ANOVA, SPSS, Chicago, Ill). **Results :** The mean decibel (dB) level for all devices under all conditions tested was 59.2 dB. By comparison, the decibel level in the center of our ICU during the day was 45.0 dB. The use of a PEEP valve reduced the noise level by 3.4 dB (no valve vs. PEEP 15 cm H_2O). Moving from 0.5 m to 1.5 m from the device reduced the noise level by 3.6 dB. The filter (No.1605, Hudson RCI, Temecula, CA) inserted in the intake port of the device reduced noise by 3.5 dB. The flow of 80 L min^{-1} compared to maximum flow reduced the noise level by 5.0 dB. The use of smooth tubing reduced the noise level by 1.0 dB. One device (Whisper Flow 2-60, Caradyne, Indianapolis, IN) produced less noise than the other devices. **Conclusion:** The EPA noise limit recommendations for a hospital unit are 45 dB during the day and 35 dB at night. This study clearly indicates that CPAP devices generate noise higher than EPA recommendations. Noise generated by CPAP devices is set by certain factors: flow setting, device in use, distance from the device, use of filter, peep valve and tubing type (order of decreasing magnitude). Health care personnel should set up and maintain CPAP devices with adequate flow, the prescribed FIO_2/CPAP levels and the lowest possible sound exposure.

OF-01-060

THE "SPIROCARD" SPIROMETER COMPARES FAVORABLY WITH TWO CURRENTLY USED SPIROMETRY SYSTEMS.

Sung-Chul Lim MD, Dale Marks RRT, Alexander Adams MPH,RRT.
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Background: The importance of accurate spirometry testing has been repeatedly addressed in American Thoracic Society (ATS) guideline statements. A new category of abbreviated spirometry testing, office spirometry, has been recommended to facilitate testing of all cigarette smokers over 45 y/o and younger individuals with respiratory symptoms. To meet this public health need, manufactorers have developed an array of portable spirometers. The SpiroCard (QRS diagnostic, Plymouth, MN), a type 2 PCMCIA card, serves as a spirometer that adapts to laptop computers. **Method**: We compared indices of pulmonary function (FVC, FEV1, FEF25-75%, and PEFR) measured by the SpiroCard, a complete pulmonary function test system (Sensormedics, Yorba Linda, California) and a currently used portable unit (Koko, Wrightsville, PA). Seven normal volunteers performed spirometry testing on each instrument. Testing was performed to meet ATS guidelines requiring at least three "acceptable" efforts. The data was analyzed by ANOVA (super ANOVA, SPSS, Chicago, IL).
Results: Indices of pulmonary function measured by the SpiroCard were not significantly different from the Sensormedics or Koko spirometers (Table 1). There were no observable, systematic differences between the appearances of expiratory flow waveforms generated by the three spirometers.

Table 1. Values of pulmonary function indices between the devices (mean±s.d.)

	FVC (L)	FEV1 (L)	$FEF_{25-75\%}$ (L/s)	PEFR (L/s)
SpiroCard	4.43 ± 1.37	3.71 ± 0.89	4.34 ± 0.72	9.77 ± 1.95
Sensormedics	4.51 ± 1.43	3.75 ± 0.97	4.08 ± 0.51	8.71 ± 2.30
Koko	4.75 ± 1.34	3.85 ± 083	4.01 ± 0.57	9.89 ± 1.84

Conclusions: In normal volunteers, the SpiroCard spirometer produced similar indices and tracings to PFT systems in current use.

OF-01-062

ESTABLISHING APPROPRIATE VENTILATOR PARAMETERS USING AN IN LINE RESPIRATORY MONITOR DURING MANUAL VENTILATION

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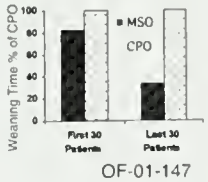
INTRODUCTION Appropriate settings for initiating conventional mechanical ventilation (CMV) are often estimated by manual ventilation with an in-line pressure gauge. Initial high frequency oscillatory ventilator (HFOV) parameters are estimated from CMV mean airway pressure (MAP) and peak inspiratory pressure (PIP). If the patient acutely decompensates, it becomes necessary to reevaluate ventilator parameters. Reevaluation of CMV rate and PIP has traditionally been done by manual ventilation with an in-line pressure gauge. Estimation of MAP for HFOV has not been possible with this technique. We describe using the Meteor (Mallinckrodt) portable respiratory mechanics monitor to measure the PIP and MAP needed to make HFOV adjustments.
CASE SUMMARY A 2.2 kg, 33 wks. gestational age, twin B, male infant presented with severe RDS requiring surfactant administration (times 3) and HFOV. On day of life 2 the patient precipitously developed severe hypoxia (PaO_2=27 torr,) and hypercarbia (pH = 7. 22, $PaCO_2$ = 65 torr) with HFOV settings 10 Hz, delta P = 40 cm H_2O, MAP = 15.7 H_2O, FIO_2 = 1.00. Manual ventilation with the Meteor was initiated to assess the MAP and PIP required to reverse the hypoxia: at MAP of 30 cm H_2O and PIP = 40 cm H_2O, the pre/post ductal saturation of 60%/57% increased to 98%/100%. Subsequent ABG during manual ventilation: pH = 7.20, $PaCO_2$ = 67 torr, PaO_2 = 283 torr. The patient was placed back on HFOV at MAP = 30 cm H_2O and delta P = 45. Two hours after the HFOV settings were increased, the arterial blood gas revealed pH = 7.31, $PaCO_2$ = 49 torr, PaO_2 = 468 torr. HFOV settings were rapidly decreased over the next 12 hours to FIO_2 = 0.50, delta P = 22 cm H_2O, MAP = 15 cm H_2O. Frequency remained at 10 Hz. All ventilator parameters, except frequency, were weaned below pre-intervention levels. The patient was later switched to conventional ventilation 2 days later and extubated without incident. **DISCUSSION** Conventional aneroid pressure gauges used during manual ventilation do not measure MAP, which is a critical variable during HFOV. Furthermore, PIP readings are only estimates based on the operator's assessment of needle movements. The Meteor is a superior alternative for conventional pressure gauges, providing digital displays of MAP, PIP, PEEP, inspiratory time, I:E, tidal volume, respiratory rate along with other indices and graphics. These features also make it valuable for spot-checking conventional pressure controlled ventilation. In this case study the Meteor provided objective data for rapid optimization of HFOV which facilitated weaning to parameters below pre-intervention levels. Use of this new adjunctive technology provides therapists a valuable tool for managing ventilated patients.

OF-01-072

CLINICIANS QUICKLY LEARN TO UTILIZE IMPROVED ACCURACY AND RELIABILITY OF THE NEW GENERATION OF PULSE OXIMETERS

Stephanie K. Rostow, RRT, Lead Therapist, Charles G. Durbin, Jr., MD, Professor of Anesthesiology and Surgery, University of Virginia Health System, Charlottesville, Virginia

During a prospective study of the impact of improved oximetry on clinical practice, we found that caregivers more rapidly weaned cardiac surgery patients from a high FiO_2 (as well as obtaining fewer ABGs), when they had access to data from a Masimo SET® Oximeter (MSO) as compared to a conventional pulse oximeter (CPO) (Ohmeda 3740). [1,2]. We demonstrated that data from the MSO was more reliable than that from CPO, with less oximeter failure and "down time", however, this information was not available to caregivers during the study. In an attempt to see how this change was "learned", we studied the change in weaning speed over time during the study.
METHODS: After obtaining consent, 86 adult patients were studied following CABG. On arrival in the ICU, both a CPO and a MSO were attached to the same hand of each patient and the output from both monitors continuously. Patients were randomly assigned to have the display of only one of the devices available to the bedside caregivers with the other device "blinded". No other clinical interventions were altered. No information about the expected or actual performance of the MSO was provided to caregivers at any time. We determined the time until weaning to FiO_2 = 0.4, until extubation, and number of ABGs. We compared the first 30 patients enrolled to the last 30. The weaning time with the CPO was used as control time for comparison (100%).
RESULTS: There was no difference in the demographics of the patients between any group. In the first 30 patients, there was a small (insignificant) difference with the MSO patients who weaned in 83% of the time of CPO patients. Of the last 30, those with the MSO weaned in 32% of CPO weaning time (p=<.05). There were fewer ABGs during weaning with the MSO over the entire study (2.7± 1.2 vs. 4.1 ± 1.6 MSO vs. CPO, p<0.001) but this difference did not change over time.
CONCLUSIONS: This study shows that clinicians learned to identify better monitoring technology. This experimental design (randomized patients and blinded clinicians) is a powerful method to evaluate the impact of new technology. The demonstration of a positive change in behaviour over time is strong support for the idea that evaluation and learning are taking place. We suggest that this is a better way to study and evaluate innovation and improvements in technologies in a clinical domain.



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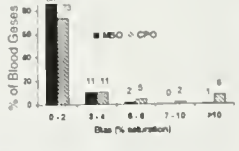
OF-01-147

IMPROVED ACCURACY OF THE MASIMO SET® OXIMETER (MSO) INCREASES CAREGIVER CONFIDENCE IN SATURATION VALUES

Stephanie K. Rostow, RRT, Lead Therapist, Charles G. Durbin, Jr., MD, Professor of Anesthesiology and Surgery, University of Virginia Health System, Charlottesville, Virginia, USA

During a prospective study of the impact of improved oximetry on clinical practice, we found that caregivers more rapidly weaned cardiac surgery patients from a high FiO_2 while obtaining fewer ABGs, when they had access to data from an MSO as compared to a conventional pulse oximeter (CPO) (Ohmeda 3740). [1,2]. In this report we examine the relationship between saturations determined from clinically indicated ABGs and the saturations reported simultaneously to evaluate their accuracy.
METHODS: After obtaining consent, 86 adult patients were studied following CABG surgery. On arrival in the ICU, both a CPO and a MSO were attached to the same hand and the output from both monitors continuously recorded until 4 hours following extubation or for a maximum of 24 hours. Patients were randomly assigned to display only one device to the bedside caregivers with the other device "blinded". No clinical interventions were changed. Any time an ABG was obtained, comparison of the saturation reported for each oximeter and that calculated from the ABG was made.
RESULTS: 283 ABGs were studied,134 while the MSO was unblinded and 149 while the CPO was unblinded. The bias (mean ± sd) was calculated as the difference between the SpO_2 and the average of the SpO_2 and SaO_2, for each oximeter, for all blood gas samples obtained. For the MSO the difference was .53 ± 1.7%; for the CPO -.82 ± 2.8%, p<.05. Limiting analysis to unblinded data failed to improve the results for the CPO. The frequency distribution of the bias was counted and grouped (Figure). MSO produced a bias >5% significantly less frequently than CPO, 3% versus 15% of all ABGs (p<.05).
CONCLUSIONS: The MSO had a smaller bias then CPO. The CPO had more errors greater than 5% saturation. This improved accuracy, as demonstrated by the smaller average bias and the narrower range of biases seen with the MSO device, is one reason why clinicians had greater confidence in the MSO data, weaned patients faster and obtained fewer confirmatory ABGs in our study patients.



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OF-01-148

BENCH COMPARISON OF FOUR SPIROMETERS WHICH USE DISPOSABLE FLOW TRANSDUCERS

Bliss PL, Dirks AJ, McCoy RW, Adams AB
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Background: In recent years many new, low-cost spirometers have become available. Some of these spirometers, in order to control cost and provide infection control, utilize a disposable resistance element as a flow transducer. Manufacturing tolerance dictates that each of these elements will be slightly different, so a calibration number is input into the spirometer before use. This calibration number provides the spirometer with the required information to accurately estimate instantaneous flow from the pressure data it receives. We wondered whether this system provides consistent results. **Methods:** Four commercially available spirometers, Renaissance II (Mallinckrodt), Simplicity (Mallinckrodt), SpiroCard (QRS Diagnostic), and Sensaire (QRS Diagnostic) were challenged with a Flow – Volume Simulator (Hans Rudolph Inc.) that delivered a known FVC and FEV1. Three of the standard ATS waveforms (volume waveforms 2,12 and 17) were used. Five disposable flow elements were used for each device, selected from different manufacturing lots. The same selection of elements was used for the two Mallinckrodt devices. FVC and FEV1 values were recorded from each trial as reported by the device, and compared to the values reported by the simulator. **Results:** The spirometers reported different values than the simulator, as shown in the following table. The average and the range (maximum – minimum) for each set of flow elements is included. All data is expressed as % error.

% ERROR		Volume 2		Volume 12		Volume 17		
		FVC	FEV1	FVC	FEV1	FVC	FEV1	Average
Renaissance II	Error	1.5	2.1	1.7	3.5	1.7	2.5	2.1
	Range	2.1	1.8	1.0	1.5	0.9	1.0	1.4
Simplicity	Error	2.8	3.0	3.0	4.6	3.0	3.5	3.3
	Range	1.4	1.4	1.1	1.5	1.6	1.7	1.5
SpiroCard	Error	-2.7	-2.9	-2.4	-1.5	-2.0	-1.7	-2.2
	Range	1.6	1.6	1.6	1.8	1.2	1.0	1.5
Sensaire	Error	0.1	-0.2	-0.5	1.6	-0.9	-0.3	0.0
	Range	0.6	0.6	0.9	0.6	1.6	1.6	1.0

Discussion: The flow volume simulator delivers gas at ambient temperature and humidity. Spirometers on the other hand assume that the gas entering the flow element is at body temperature and humidity, and must assume some amount of cooling. This may create a systematic error in the measurements. **Conclusion:** The uncertainty introduced by the disposable flow elements is low, no greater than 1.5%. The difference between spirometer models, however can be as high as 5.5%, which should be considered, especially when testing the same patient on different devices.

OF-01-161

CONSCIOUS SEDATION MONITORING BY RCP DURING BRONCHOSCOPY

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Statement of Problem/Opportunity: Diagnostic and therapeutic bronchoscopy frequently requires the use of either minimal sedation (anxiolysis) or moderate sedation/analgesia ("conscious sedation"). In many hospitals RCPs assist the physician with the bronchoscopic procedure, but a registered nurse monitors patient's physiologic response during-and-post procedure. The dependence on a RN can create scheduling problems, delays in procedure start times, and delays in patient and physician times. We recognize an opportunity to develop a cross-training program for RCPs in conscious sedation monitoring to address these delays while adhering to high standards of procedural assessment.

Plan: Develop a core group of RCPs skilled in conscious sedation monitoring, and monitor the impact on the identified quality indicators (timeliness, procedure delays).

Do: The RC department took steps to implement the plan.

- Familiarized themselves with the hospital policies on conscious sedation and monitoring
- Obtain Medical Direction support, and Administrative support.
- Develop and implement a training program equivalent to RN expectations including: ACLS certification, IV certification, Sedation principles, Effects of Anesthesia, Pre, during and post-operative assessment, Competency testing
- Strict adherence to protocol for recovery and discharge of the bronchoscopy patient.

Check: Monitor performance with specific focus on pre, during, and post procedural assessment, patient monitoring and documentation. Compare results to RN attended conscious sedation procedures in other areas of the hospital.

Results: 362 RCP monitored bronchoscopy procedures have been performed since inception. The performance of RCP monitored conscious sedation equaled or exceeded nurse attended conscious sedation performance in all monitored categories; pre procedural documentation, assessment, monitoring, medication and IV management, post-procedural care and documentation. There were neither adverse or consequential events, nor any requirements for reversal medications or assisted ventilation secondary to the bronchoscopy procedure.

Conclusion: The Joint Commission on Accreditation of Hospital Organizations (JCAHO), defines "conscious sedation" as a drug induced depression of consciousness during which patients respond purposefully to verbal commands...tactile stimulation ...no interventions required to maintains a patent airway, spontaneous ventilation is adequate...RCPs by nature of the education and training, are ideally suited to monitor patients during endoscopic procedures. We have demonstrated that properly trained RCPs can safely and efficiently monitor patients requiring conscious sedation.

OF-01-178

BI-LEVEL POSITIVE AIRWAY PRESSURE (PAP) IN PATIENTS PRESENTING TO THE EMERGENCY DEPARTMENT WITH A PRIMARY DIAGNOSIS OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE.

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Background: The use of noninvasive ventilatory support has gained popularity over the last decade. The technique has been shown to decrease work of breathing and increase the functional residual capacity of patients in acute respiratory distress of cardiac, pulmonary, or neurologic origin. This study addresses the use of Bi-level PAP in Emergency Department (ED) patients presenting with a primary diagnosis of Chronic Obstructive Pulmonary Disease (COPD) resulting in acidosis and hypercapnia. The aim is to evaluate the impact of Bi-level PAP on arterial blood gases, oxygen requirements, hospital admission to a regular nursing floor (RNF) vs an intensive care unit (ICU), and avoidance of intubation. **Method:** The sample was comprised of 17 patients presenting to the ED with a primary diagnosis of COPD. Separate data collection sheets were utilized for all patients placed on the Bi-level PAP system. Patients were assessed and rated on their intensity of sensation using a modified Borg Dyspnea Category Scale with 0 being nothing at all and 10 being maximal. The patients were managed by the physician and respiratory therapist in the ED with Bi-level PAP settings adjusted to patient tolerance. Inspiratory Positive Airway Pressure/Expiratory Positive Airway Pressure (IPAP/EPAP) were set for patient comfort, ABG/saturation, and control of ventilation. Averages were 14/7 respectively. All patients were in the spontaneous/timed (S/T) mode. Breaths/minute were set two to five below the patient\'92s spontaneous rate (average 25). All patients had continuous ECG and pulse oximetry monitoring.

Results: Table 1 presents arterial blood gas (ABG) mean with ranges in parenthesis and dyspnea index. Patients\'92 oxygen requirements before Bi-level PAP averaged 40% which increased to 44% after initiation of treatment. Intubation was not required in any of the 17 patients. Four (24%) were admitted to an ICU; thirteen (76%) went to a RNF and were successfully managed with Bi-level PAP. **Conclusion:** Bi-level PAP decreased the work of breathing and improved the ventilation of patients presenting to the ED with a primary diagnosis of COPD. Additionally, intubation was not required in any of the patients thus avoiding complications such as airway trauma, nosocomial infection, and death.

Table 1: ABG / Dyspnea Index

Before (n=17)	After (n=17)}
pH: **7.20** (7.11-7.29)	pH: **7.31** (7.24-7.38)}
PaCO2: **95** (55-156)	PaCO2: **72** (37 - 106)}
PaO2: 77 (47-100)	PaO2: 67 (53 - 86)}
HCO3 : **38** (27-57)	HCO3 : **37** (25-62) }
% Sat: **.90** (.76-.99)	% Sat: **.89** (.82-.96)}
Dyspnea index:7	Dyspnea index: 3

OF-01-189

PERFORMANCE OF PULSE OXIMETER TECHNOLOGIES IN A PEDIATRIC SLEEP LAB SETTING.

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Background: Newer pulse oximeters have been developed to be motion resistant. However, they have not yet been evaluated in a pediatric sleep laboratory, a setting where manual scoring for suspect pulse oximetry values is routine. **Methods:** While evaluating new pulse oximeter technology, we obtained simultaneous data from two versions of Masimo pulse oximeters (Quartz Q-400 and Masimo Radical) and from a Nellcor device (N-200). Events were randomly selected for analysis, an "event" being a desaturation of ≥ 4% registered by either oximeter. In series 1, comparisons were made in 24 patients between a Quartz in 4 second averaging time and the N-200 set in their shortest, 3 to 5 second averaging (Mode 2). In series 2, 22 patients were studied comparing a Radical with 2 second averaging to the N-200, again in Mode 2. **Results:** Interobserver agreement for event classification was 93%. Series 1: 88% of 220 wakeful events and 38% of 194 sleep events were classified as motion artifact on the N-200. Neither the Q-400 nor transcutaneous oxygen confirmed a drop in the majority of these cases. During sleep, there were 119 events detected by either or both the N-200 and Q-400: 113 (95%) by the N-200 versus 82 (69%) by the Q-400. For these 119 events, the extent of desaturation was slightly less for both Q-400 than the N-200 oximeter, 4.5 ± 2.4% versus 5.5 ± 2.5%, respectively. Series 2: The extent of desaturation was slightly larger for the Radical. The Radical detected more non-artifactual desaturation events occurring during sleep than the N-200, 90% versus 76% ($C^2 = 9.9$, $p<0.01$). **Conclusions:** Both Masimo pulse oximeters register many fewer false desaturations due to motion artifact. Using 4 second averaging, a Q-400 detected significantly fewer SaO_2 dips than the N-200 but using 2 second averaging, the Radical detected more SaO_2 dips than the N-200. These findings suggest that in a pediatric sleep laboratory, use of the Radical pulse oximeter with short averaging times could significantly reduce workload and improve reliability of detecting desaturations.

OF-01-191

BRONCHIAL PROVOCATION TESTING IN MILITARY APPLICANTS WITH HISTORY OF CHILDHOOD ASTHMA: DO PRE-CHALLENGE SPIROMETRY RESULTS PREDICT THE OUTCOME OF BRONCHIAL PROVOCATION TESTING? Rikki S. Bruinsma, RRT, CPFT, St. Luke's Hospital, Jacksonville, FL.

Background: The St. Luke's Hospital Pulmonary Lab was contracted by the local Military Entrance Processing Station (MEPS) in 1997 to perform methacholine challenge testing on 71 military applicants who had indicated a history of childhood asthma or asthma-like symptoms. The results of the tests were reviewed to determine if there were significant differences in the pre-methacholine challenge Forced Expiratory Volumes (FVC), Forced Expiratory Volumes, one-second (FEV1), FVC/FEV1 ratio and Peak Expiratory Flow Rates (PEF) to establish if a positive response to the bronchial provocation testing could be predicted. **Method:** A retrospective review of the results of bronchial provocation studies was performed on military applicants from 1997 through 2000. Testing was performed using the MedGraphics, BreezePF Pulmonary Function Software™. ATS criteria was used to certify all reported results. Each applicant included in the review performed a minimum of three pre-challenge FVC maneuvers. Sixty-three applicants met Mayo Clinic protocol for high dose methacholine challenge testing by achieving an FEV1 ≥ 70% of predicted value. Each of these applicants then received one breath of 25mg methacholine. Following a 3-minute wait time, post-challenge FVC maneuvers were obtained. If there was < a 20% decrease in an applicant's FEV1, up to 4 additional breaths of 25mg methacholine were given. Following an additional 3-minute wait time, FVC maneuvers were again repeated. A 20% or greater decline in pre-challenge FEV1 results indicated a positive study. **Results:** The following table outlines the results, comparing those who had < a 20% decline in their FEV1 results to those who had a ≥ 20% decline:

	Population With < 20% decrease in FEV1	Population With ≥ 20% decrease in FEV1
Sample Size (Male / Female)	18 (12 / 6)	45 (34 / 11)
Mean Age, years (± SD)	20.3 (± 3.8)	19.8 (± 3.1)
Mean Pre FVC (% pred ± SD)	96.3% (± 10.4)	92.7 % (± 9.1)
Mean Pre FEV1 (% pred ± SD)	96.7% (± 10.5)	88.5 % (± 8.2)
Mean Pre FEV1 / FVC % (± SD)	85% (± 5.1)	81% (± 5.7)
Mean Pre PEF (% pred ± SD)	113% (± 16.5)	107 % (± 14.6)

Using the F-Test with a 95% confidence level, results show no significant differences in the pre-challenge FVC (p=.23), FEV1 (p=.09), FEV1/FVC (.33) or PEF (.25) test results to indicate whether or not a particular MEPS applicant may or may not have a 20% or greater response to bronchial provocation testing using methacholine. **Conclusion:** Based on the results, prediction of positive methacholine challenge testing in the military applicant who presents with a history of childhood asthma can not be made based on pre-challenge spirometry values.

OF-01-195

IMPROVED PULSE OXIMETER SATURATION MONITORING DURING SIMULATED LOW PERFUSION CONDITIONS Kelly Jager RRT, Charles Porges, Paul Mannheimer MS, Nellcor, Pleasanton, CA

BACKGROUND: Pulse oximetry technology has continued to improve over the years due in part to better hardware and software signal processing. This has enabled the user to expand the patient population that can be reliably monitored. One of the most difficult conditions for pulse oximetry technology is to accurately monitor patients with a weak pulse (typical during "low perfusion") which is often exacerbated when the oxygen saturation (SpO_2) is also low. The purpose of this study was to determine the lowest simulated pulse amplitude at which three different generations of pulse oximeters could accurately read SpO_2 and pulse rate (PR) and thus compare the progress in technology. **METHOD:** A computer-controlled SpO_2 and PR simulator (Bio-Tek, Index 2) was used to simulate SpO_2 of 98% and 70% while the PR was kept constant at 90 bpm. The signal strength was then diminished until SpO_2 or PR was either not reported within 25 seconds or inaccurate by ≥ 2% saturation points or ≥ 2 bpm. Three instruments of each model were used for each test. A paired t-test was used to determine statistical significance. A p value of < 0.05 was considered significant. **RESULTS:** Results are shown in Table 1.

"Generation"	Pulse Oximeter	Model Lowest Mean %Signal Strength Obtained at SpO_2 Value	
		98% SpO_2	70% SpO_2
2nd	N-200	0.16	0.16
3rd	N-3000	*0.06	*0.14
4th	N-395	*0.03	*0.03

Table 1

*p < 0.05 compared to the N-200, * p < 0.05 compared to the N-3000 and N-200

CONCLUSION: There has been a five-fold improvement in the ability of new generation pulse oximeters (N-395) to acquire and accurately read the set SpO_2 and PR values during simulated low signal strength conditions when compared to early generation (N-200) pulse oximeters. Further studies are necessary to determine the clinical relevance for patients with low levels of perfusion.

OF-01-217

USE OF ABG IN TRAUMA FOR EARLY RECOGNITION OF ACIDOSIS AND HYPOXEMIA by Kathy Cadden, RN; Elizabeth Norman, B.S. RRT, RCP; and Julie Booth, MS, CPHQ. Providence Holy Cross Medical Center, Mission Hills, Ca.

Background: The ICU Trauma Team had a concern with timeliness of interventions for acidosis and hypoxemia. After a review of the literature and data information from other trauma centers, it was determined that no guideline existed for the early recognition and treatment of acidosis and hypoxemia. To establish baseline data, an initial chart review (cases from Apr 1998 - Apr 1999) was completed after establishing what required data elements were needed for the database. Initial chart review analysis revealed that it took approximately 13.8 hours from arrival to the emergency room to identification of acidosis or hypoxemia. The resolution rate for acidosis was 65% and 58.3% for hypoxemia within initial 24 hrs of arrival.

Method: In order to identify either of these conditions earlier and therefore, be able to treat earlier, a 2 month pilot project was implemented. The pilot project called for an ABG be obtained in the ED if the patient was to be admitted to ICU unless 1.) contraindicated by MD, or 2.) the patient was going from the ED to Surgery. Respiratory Therapy was to draw ABG based on set criteria.

Results: 89% of the Trauma patients in the pilot project had acidosis/hypoxemia on 1st ABG drawn. The time from identification to resolution of acidosis was decreased by 29.4%. (p < .05) The time from identification to resolution of hypoxemia was decreased by 35.6%. (p < .05) The resolution rate of Hypoxemia/Acidosis within initial 24 hrs of arrival = 93.75%. A significant implication of this improvement resulted in an actual charge savings of $1850 which is the ICU Trauma bed rate minus ABG charge.

Conclusion: These results were presented to Medical Staff and a procedure was approved for Respiratory Therapy to routinely perform an ABG on all Trauma patients in the emergency room who would be admitted directly to the ICU.

OF-01-209

A RETROSPECTIVE RANDOMIZED COMPARISON OF CORRELATION AND TURNAROUND TIMES IN SERIAL TESTING OF CARDIAC MARKERS PERFORMED BY RESPIRATORY CARE PRACTITIONERS UTILIZING A POINT OF CARE TESTING DEVICE (TRIAGE®, BIOSITE DIAGNOSTICS) TO CLINICAL LABORATORY BECKMAN CX7 AND BAYER ACS 180. Stanley M. Baldwin, MBA, RRT, Elizabeth Fischer, RPFT, Daniel G. Walters, M.D., Department of Pulmonary Services, Desert Regional Medical Center, Palm Springs, CA

Background: Early and accurate evaluation for patients with chest pain is critically important for their appropriate triage and management. Point of care testing (Triage®, Biosite) coupled with diagnostic algorithms have shown that 100% of Acute Myocardial Infarction can be diagnosed by 90 minutes. In addition, Press-Ganey data shows a strong correlation between patient dissatisfaction and longer Emergency Department waiting times. One of several improvements would be to expedite laboratory data to the physicians to decrease time to patient disposition. This study compared correlation and turnaround times of point of care Triage® device from Biosite Diagnostics with analysis done by respiratory care practitioners in the Emergency Department to Beckman CX7 and Bayer ACS 180 in the clinical laboratory setting. **Methods:** 30 paired data turnaround times from draw time to being reported to the physician were selected using a table of random numbers. Correlation of the two methodologies was done by parallel study of 35 blood samples. Troponin I and Myoglobin were analyzed by Bayer ACS 180 and CK MB by Beckman CX7 in the clinical lab. Both clinical laboratories use serum. The Triage Meter® ran all three cardiac markers (Troponin I, CKMB, Myoglobin) from whole blood. The device is classified as moderately complex, allowing testing to be done by respiratory care practitioners. Statistical analysis using a t-test to compare turnaround time and a correlation co-efficient was calculated for regression analysis of all three cardiac markers and mean difference to determine bias.

Variable	Bias	Clinical Lab Serum Sample n=35	Triage Meter ED Whole Blood Sample n=35	Correlation Coefficient Regression Analysis (R)
CKMB	1.94	3.26 ± 9.4	5.19 ± 14.13	0.99
Myoglobin	36.20	80.2 ± 109.7	116.4 ± 98.40	0.94
Troponin I	-0.30	0.513 ± 1.9	0.210 ± 0.44	0.99
				0.97 = Mean
Turnaround Time (minutes)		59.06 ± 18.34	34.83 ± 19.01	P< 0.01

Results: The correlation between the two devices using different methodologies was high with an average R=0.97 for the three markers. The turnaround time for results was statistically significant with a P<0.01 for cardiac markers being done point of care by respiratory care practitioners in the emergency department versus the clinical laboratory. **Conclusion:** The use of a point of care device by trained respiratory care practitioners to measure Troponin I, Myoglobin, and CKMB cardiac markers can significantly reduce turnaround time of critical data to physicians and reach a target time of 90 minutes to assess chest pain.

OF-01-222

SURVEY OF PHYSICIANS TO IDENTIFY THEIR EXPECTATIONS OF RCPs IN PATIENT ASSESSMENT PROCEDURES

Robert L. Wilkins, Ph.D., RRT, FAARC, Jacqueline Evans, BS, CRT, and Lennard Specht, M.D.

The exact role of RCPs in patient assessment is not well defined. The purpose of this study was to identify local physician expectations of RCPs for the application and interpretation of various assessment procedures. A survey was developed that called for physicians to indicate on a scale of 1 to 5 (1= never; 2= rarely; 3= occasionally; 4= often; and 5= always) how important they perceive it is for RCPs to be able to interpret or perform 20 commonly utilized patient assessment tests or procedures. The survey was mailed to 24 physicians who care for patients in the medical and surgical intensive care units at Loma Linda University Medical Center and the Jerry L. Pettis Veterans Administration Memorial Medical Center in Southern California. Nineteen (76%) of the 24 surveys were returned. The assessment procedures rated highest included: assess lung sounds (4.8), interpret ABGs (4.5), interpret PFTs (4.3), assess and interpret vital signs (4.3), interview patient to clarify symptoms (4.2), and percuss the patient's chest for resonance (4.0). The procedures consistently rated low were: interpret EEG (1.8), assess abdomen (2.3), interpret sleep studies (2.3), and interpret echocardiography (2.4). A total expectation score for each completed survey was determined by adding the scores from each of the 20 assessment procedures listed. The average total score was 67.0 (S.D. = 10.7) on a scale from 20 to 100. The total expectation score did not vary by years of experience in patient care or type of medical specialty (e.g., pulmonary vs. surgery). The results indicate that the physicians completing our survey generally have high expectations of RCPs for the application of patient assessment techniques that involve direct evaluation of lung performance or condition.

OF-01-227

ANALYTICAL PERFORMANCE OF GLUCOSE AND LACTATE SENSORS IN THE GEM PREMIER 3000 ANALYZER

Sohrab Mansouri, Clarke Xu, Melanie Shin Instrumentation Laboratory, 101 Hartwell Ave, Lexington, MA 02421 Background: The GEM line of blood analyzers are unique in that they are using a disposable cartridge containing all elements necessary for sample analysis including miniaturized sensors, reagents, fluidic system and waste container. The latest cartridge for the GEM Premier 3000 analyzer has capability to measure pH, PCO2, PO2, sodium, potassium, calcium, glucose, lactate, and hematocrit in 150 mL sample volume. The cartridge can analyze up to 450 samples and can be operated continuously for up to three weeks. In this report we present the analytical performance characteristics of the glucose and lactate sensors. Method: The glucose and lactate sensors are integrated in a plastic sensor card alongside the other gas, electrolyte and hematocrit sensors. The glucose and lactate measurements are based on amperometric electrochemical detection with three electrode configurations consisting of a platinum working, reference and counter electrodes. The working electrode is fabricated of a composite membrane containing inner, enzyme, and outer layers. The enzyme later has glucose oxidase for glucose and lactate oxidase for lactate detection. The inner and outer membranes are optimized to minimize the effects of commonly existing interfering compounds and the oxygen level in whole blood. The analytical performances of the glucose and lactate sensors were compared against standard laboratory bench analyzers (ABL 605 from Radiometer and Synthesis 1745 from Instrumentation Laboratory). Six levels of glucose and lactate were evaluated using fresh, heparinized whole blood from healthy volunteers. The samples were spiked or diluted and tested in 4 replicates per run. The blood runs were conducted once per week for three weeks using 7 cartridges from 3 different production lots. Results: The bias results are calculated using pooled GEM results and are compared with the bench analyzer results. Also shown in the table are within run SD and pooled SD to determine imprecision per level.

GEM Mean		Bench Mean		Avg. Within Run SD		Total Pool SD	
Glucose mg/dL	Lactate mmol/L	Glucose mg/dL	Lactate mmol/L	Glucose mg/dL	Lactate mmol/L	Glucose mg/dL	Lactate mmol/L
30.0	0.55	30.2	0.57	1.5	0.08	1.6	0.08
53.1	1.41	53.3	1.43	2.1	0.08	2.1	0.09
97.6	2.40	97.8	2.57	3.0	0.06	3.6	0.10
177	5.16	176	5.31	6.9	0.14	7.5	0.18
348	8.29	343	8.50	14.9	0.24	15.3	0.31
441	10.1	432	10.6	21.1	0.30	21.4	0.49

Conclusion: Our results show that the overall performance of the glucose and lactate sensors in GEM Premier 3000 analyzer compares favorably to standard laboratory analyzers and blood precision values are well within clinical limits.

OF-01-232

EVALUATION OF EXERCISE-INDUCED BRONCHOSPASM AND OBESITY IN ADOLESCENTS.

R. Randall Baker, PhD, RRT, RCPT; Matthew C. Humphries, BS; Dennis R. Ownby, MD; Paule Barbeau, PhD; and Bernard Gutin, PhD. Medical College of Georgia, Augusta, GA.

BACKGROUND: Exercise intolerance occurs when subject responses to an exercise challenge fail to achieve age- and gender-specific norms. This condition can be associated with exercise-induced bronchospasm (EIB) and sedentary behavior. In addition to limiting exercise capacity, physical inactivity frequently leads to obesity. The incidence of both EIB and obesity are increasing among American youth. The purposes of this preliminary study were to (1) assess the effect of a modified symptom-limited, maximal oxygen consumption exercise test on detecting EIB, and (2) examine the prevalence of obesity and EIB in a sample of high school students. METHODS: We tested 28 students 14 to 18 years of age recruited from local high schools enrolled in an ongoing study that is examining relationships of level of fitness and fatness to various cardiovascular disease risk factors. Inclusion criteria included ethnicity of either white or African-American and the absence of chronic cardiovascular conditions. Each student participated in a maximal oxygen consumption treadmill test. The test ramp was designed for students to approach their maximum heart rate within 10 minutes. Each test was terminated when either a heart rate of 200 beats/minute was achieved or when the student could no longer continue. Spirometry was performed immediately prior to and five minutes post exercise using the best of three trials. Body mass index (BMI) was calculated as weight in kilograms/height in meter^2. RESULTS: Post-exercise spirometry was successfully completed in 79% (n =22) of subjects. Fourteen percent (3 of 22) of subjects experienced EIB, as demonstrated by a post-exercise fall in FEV_1 of $\geq$ 12%. Five of 28 subjects (18%) were obese having a BMI that was $\geq$ the 95th percentile for age and gender or > 30 kg/m^2. There were no significant differences between mean baseline FVC, FEV_1, FEV_1/FVC ratio, and FEF25%-75% values in obese and non-obese subjects using one-tailed T-tests. In addition, Pearson correlation coefficients among BMI and baseline lung function parameters were weak and not significant. CONCLUSION: Our findings demonstrate that the exercise challenge used in this protocol is sufficient to elicit EIB. In addition, the data indicate a substantial rate of both EIB and obesity in this sample of high school students. However, there was no significant association between obesity and EIB.

OF-01-235

Comparison of Continuous Cardiac Output (CCO) to Bolus Thermal Dilution Cardiac Output (TDCO) Using the Edwards Lifesciences Vigilance Monitor

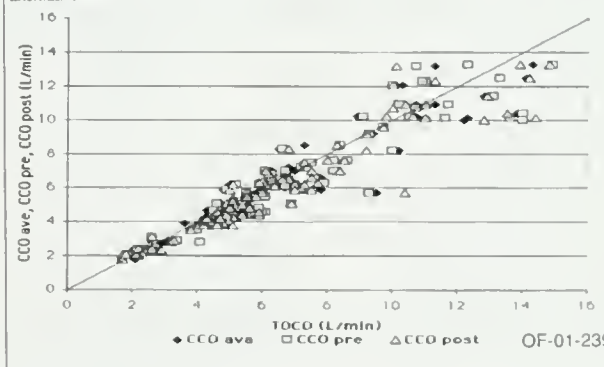
Mark Siobal BS RRT, Richard Kallet MS RRT, Julin Tang MD, Respiratory Care Services, San Francisco General Hospital, UCSF Department of Anesthesia.

Background: The Vigilance Monitor measures CCO by introducing small pulses of energy to a thermal filament equipped pulmonary artery catheter while recording blood temperature. Cardiac output is calculated using the conservation of heat equation. CCO is displayed continuously as a running average of 5 - 10 minute intervals. CCO values are calculated as often as every 30 - 60 seconds. The monitor also can be used to perform traditional TDCO. We compared CCO to the TDCO method using the Vigilance monitor in medical-surgical ICU patients.

Method: TDCO was compared to: CCO 5 to 10 minute running average (CCOave), CCO immediately pre TDCO (CCOpre), and CCO immediately post TDCO (CCOpost). A total of 111 comparisons were done in 16 patients. TDCO was performed every 4 - 6 hours. A 10 cc room temperature injectate solution was used. Indicator solution injection using standard technique was timed at end inspiration with the patient in a supine or semi fowlers position. Three TDCO determinations (within ± 0.5 L/min) were averaged and compared to CCO values. Results were analyzed using simple regression. Differences were examined using the Bland-Altman method.

Results: The mean TDCO, CCOave, CCOpre, and CCOpost were 5.9, 6.2, 6.3, and 6.3 L/min respectively. Regression analysis shows a very high correlation between TDCO vs CCOave, TDCO vs CCOpre, and TDCO and CCOpost (R = .92, .94, and .95 respectively, p <.0001). The mean bias and precision between TDCO and all CCO data sets was −0.4 ± 1.0 L/min.

Conclusion: Our data shows that CCO monitoring using the Vigilance monitor is a reliable alternative to intermittent TDCO determinations.



OF-01-239

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The AARC Online BUYER'S GUIDE

THE USE OF A CHEST X-RAY (CXR) IN THE TREATMENT OF BRONCHIOLITIS PATIENTS Kim Bennion RRT, BS, Julie Ballard RRT, BS, QCAT Team Members and John Salyer RRT, MBA, FAARC. Respiratory Care Service, Primary Children's Medical Center, School of Medicine, University of Utah.

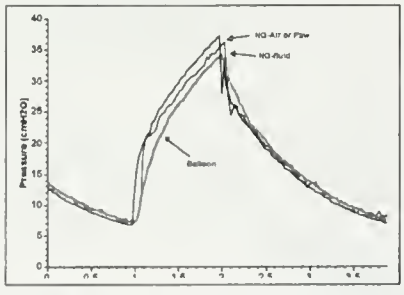
Introduction: Our hospital has a multi-disciplinary assessment team that specializes in care of bronchiolitis pts. The team is called the Quality Care Assessment Team (QCAT) and has 7 specially trained RCPs who daily assess all pts receiving any respiratory interventions. The team employs standardized protocols for treatment. A standing admit order (SAO) sheet is used by the physician when admitting a pt to a non-intensive care unit. The utilization of a CXR is not included on the SAO, therefore, a physician must order this separately. CXR is not generally recommended in uncomplicated bronchiolitis.[1,2] Nevertheless an unwarranted variation in ordering practices seems to exist at our hospital. We sought to determine CXR utilization and it's relationship to other aspects of care. **Methnd:** Data were retrospectively extracted from our data systems for the 2000-2001 bronchiolitis season. Inclusion criteria were (1) primary diagnosis bronchiolitis, (2) age ≤ 24 months, (3) only non-ICU pts and (4) APR/DRG severity of illness level of 1 (the mildest). Seeking to compare only truly uncomplicated bronchiolities, we further excluded patients who had congenital heart disease, upper airway anomalies, cystic fibrosis, bronchopulmonary dysplasia and immuno-compromised disease states. Data elements included CXR utilization, length of stay in hrs (LOS), number of nebulized bronchodilator and CPT treatments, and hospitals costs and charges. Mean differences were tested using Mann-Whitney U test, with significance set at $P<0.05$. **Results:** Of the 580 patients who met the diagnostic criteria, 52 were excluded based on pre-existing factors leaving 528 pts. We further excluded 338 due to APR/DRG severity level >1, leaving 190 pts. CXR was utilized in 42% of these low severity pts. **Discussinn:** This method of selecting pts should produce a fairly homogenous sample of low severity bronchiolitis pts. Yet 42% had a CXR. If the CXR group had indeed been sicker, we would have expected to see more respiratory interventions, yet we did not. It might be argued that the increased LOS in the CXR group indicates increased severity, but could also be explained by unwarranted practice variation. It is interesting to note that no pts in either group had any CPT. In recent years we have seen some improvement in CXR utilization, yet it still seems inappropriately high, especially in this group.

1 Paediatr. Child Health 1993:29:335-337
2 Pediatrics 1999;104;6:1334-1341

OF-01-242

A POTENTIAL FOR MONITORING ESOPHAGEAL PRESSURE WITH OPEN-ENDED, FLUID-FILLED OR AIR-FILLED CATHETERS. Alexander Adams MPH, RRT, Robert Shapiro MD, Apostolos Armaganides MD. Regions Hospital/University of MN, St. Paul, MN.

Background - Esophageal pressure (Pes) provides the best estimate available for monitoring intrathoracic, extrapulmonary pressure. Such pressure monitoring allows the calculation of work of breathing and pressure time product, important parameters to the clnician treating patients with lung injury. The Pes catheter is a perforated, balloon covered catheter used specifically for this monitoring purpose. We examined the pressure monitoring ability of conveniently available, open ended nasogastric tubes (either air filled or fluid filled) as possible substitutes for Pes catheters. Methods – In an air tight limb extending from a standard ventilator circuit we placed an esophageal catheter (Bicore, Riverside, CA), small and large bore channels from a nasogastric tube (16 ga), small and large bore channels from a fluid filled nasogastric tube and an airway pressure tap. Pressure tracings from the 6 channels were simultaneously recorded and digitized under a range of ventilator setting and impedance conditions. Signals were compared by peak pressure achieved, pressure at 90% of target, and exponential curve fitting. Results: The figure displays an example that compares 3 tracings: balloon, fluid-filled and air-filled (identical to Paw) catheters. By visual inspection and the measurements of intertracing comparisons, the esophageal catheter signal was dampened by the balloon; the Pes catheter reaches pressures more slowly and underattains peak pressures. The other catheters had better responsiveness to pressure change yet their signals displayed artifacts; the signals did not correlate to exponential fits as well as the Pes catheter. Conclusion: Fluid or air filled catheters measure pressures with greater fidelity than a standard esophageal catheter yet their signals were more susceptible to artifacts. Static pressures can be monitored by either open ended or balloon covered catheters while dynamic pressure tracings should be scrutinized for effects from dampening, phase lag or artifacts.



OF-01-252

THE ACCURACY AND REPRODUCIBILITY OF NEW RESPIRATORY CUFF MONITOR

Dick Tetsuo Miyagawa, PhD, RRT, RPT, RCET, Nono Kihara, MD, and Hiroki Goshima, BS
Showa University, College of Medical Sciences, Department of Physical Therapeutics
Kihara Hospital, Department of Respiratory Medicine
SECOM Co. LTD, Research & Develop Center, The First Medical Team

Background: The purpose of this study was to assess functional status in domiciliary patients with chronic respiratory failure using the new respiratory cuff monitor that we developed. We studied the accuracy and reproducibility of our new respiratory cuff monitor.

Methods: To assess the reliability of the our new respiratory cuff monitor, we analyzed chest and abdominal wave forms of cuff pressure change, and compared measurements of pulmonary function testing(PFT) at the same time. Twenty-one healthy subjects and twelve patients with chronic obstructive pulmonary disease (COPD) participated in the trial. We also measured couple times to know the reproducibility of this monitor in COPD patients.

Our new respiratory monitor composes of three parts. The pressure sensitization part of belt has cuff as a balloon which placed on chest and abdomen separately. Operation part consists of a pressure sensor and a pressunization pump. The change of cuff pressure converted to wave forms.

Results: The positive relationship between the change of chest and abdominal cuff pressure and respiratory rate, peak expiratory flow rate, tidal volume, vital capacity, and functional residual capacity in healthy subjects and COPD were shown. The correlation coefficients between cuff pressure and these measurements were in highly significant (0.538–0.997, $p<0.001$)(table1.).

The reproducibility of spirometry and our respiratory cuff monitor in healthy subjects had significantly reliability (table1.)

Conclusions: Our simple respiratory cuff monitor had high correlation coefficients between cuff pressure and these PFT measurements. And this monitor was seemed to be efficient to assess functional status in domiciliary patients with COPD.

(table 1.) The correlation coefficients between cuff pressure and PFT in highly subjects

		reproducibility	
	r	spirometry	cuff monitor
VC	0.787	0.972	0.944
IRV	0.538	0.850	0.851
ERV	0.793	0.862	0.936
IC	0.761	0.805	0.884
TV	0.588	0.666	0.680

OF-01-262

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OUTCOMES OF CAMP GREEN ZONE ASTHMA DAY CAMP.

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Introduction: York Hospital statistics have paralleled national findings indicating asthma as the leading DRG of pediatric admissions. Similarly, a survey of York County school nurses identified 2000 children ages 6-13 with asthma. York Hospital developed Camp Green Zone to promote patient education and teach asthma management skills in asthmatic children. Primary goals were to provide campers with the knowledge and tools needed for self-management while participating in typical summer camp activities. Methods: Measurements of knowledge, behavior, and attitude with respect to asthma were measured through pre and post testing administered to campers. Parent surveys were obtained three months after completion of camp to see if changes persisted over time. Results: Over four years, 160 campers participated in Camp Green Zone. Our data spans the last 3 years. The outcome results were evaluated in three age groups (6-7 year olds (I), 8-9 year olds (II), and 10-13 year olds (III). Group I demonstrated a mean increase in Asthma knowledge of 19%, an improvement in behavior and management skills of 14%, and an improvement in attitude of 9%. Group II evidenced a 15% increase; an 11% increase, and a 3% increase respectively. Group III saw a 17% improvement; a 16% improvement, and an 11% improvement respectively. For all three years the overall response rate from parent surveys indicated 84% of families had less disruptions from asthma. 82% reported less severe asthma episodes. The response rate from the parent surveys was 58% overall. Conclusion: Children who attend Camp Green Zone demonstrate improvements in cognitive measures of their asthma. Effects appear to improve asthma control at three months.

OF-01-025

CAREGIVER'S COMPLIANCE WITH PRESCRIBED MANAGEMENT REGIMEN FOR YOUNG CHILDREN WITH ASTHMA.

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Asthma is the most common childhood chronic disease in the US, affecting an estimated 4.8 million children under the age of 18 years. Lack of compliance with the National Education Asthma Prevention Program (NEAPP) guidelines contributes to asthma morbidity and mortality. The purpose of this study was to assess caregiver compliance with the NEAPP Guidelines. The research question guiding the researchers was: What are the patterns of medication compliance among families with young children with asthma. Ninety-two children (1-6 yrs.) with asthma and their primary caregivers were recruited from an inner-city hospital. Children's mean age was 3.9 years, 79% had moderate persistent or more severe asthma (based on physician assessment and medication regimen); mean caregiver age was 31 years, 35% of the mothers bore their first child ≤ 17 yrs.; 90% are on Medicaid and 99% are African-American. Asking how often the child received daily medications exactly as prescribed within the last week assessed self-reported medication adherence. Forty-two (46%) children followed the medication regimen as ordered. Forty-six (50%) children were not being medicated as prescribed (or under-medicated) and 4 (4%) were given more medications than ordered (or over-medicated). Twenty-six (28%) children were given medications in addition to the ones prescribed at the time of the assessment. The findings suggest the importance of generating clearly outlined medication regimens. Many children were over medicated while others were under medicated. Moreover, some children were not medicated at all according to the prescribed plan but were given other non-prescribed medications for asthma symptom relief and control. Additional research is needed to clarify reasons why caregivers do not follow medication adherence plans in the pediatric asthma population to optimize medical management, particularly in the at-risk ethnic minority populations. To improve compliance with NEAPP guidelines members of the healthcare team need to review family's medication regimens and reinforce the need to use preventive medicines at every healthcare visit.

OF-01-030

ASTHMA MANAGEMENT - WHERE TO START, HOW TO IMPROVE?

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Background: Asthma management guidelines now recommend the use of inhaler devices for convenient and effective delivery of asthma medication. The availability of pharmaceutical agents in different devices has made asthma more manageable, but has also become a source of confusion to patients and healthcare providers. Simply applying the guidelines, however, does not result in patient compliance, good inhaler technique or guarantee the success of asthma management.
Aim To identify problems related to the use of inhaler devices.
Method: A three months prospective study from July to September 2000 was conducted in the asthma-counseling clinic of a tertiary care teaching hospital. Adult and pediatric patients and their carers, who had used an asthma inhaler device for at least 2 months, were evaluated for appropriateness of asthma medication management. Appropriateness was assessed by a respiratory therapist through:
a. Inhaler demonstration by patient/carer pair and adherence to a structured checklist
b. Verbal questionnaire utilizing a standardized format
c. Review of patient prescription and file
Result: Two hundred and eleven adults (13 years and above) and 55 children were evaluated, and five different type of devices and two types of spacers were used. Numerous and important patient-related and institution-related problems were identified in 99% of patients.

Identified Problem	No.	Total No.	%
1. Inhaler technique			
Poor technique (all devices)	77	388	20
Moderate technique (all devices)	45	388	12
Ignorance about "empty" device	14	113	12
2. Compliance of Patient			
Omit morning preventer	262	263	99
Reliever misuse	156	210	74
Long acting reliever misuse	34	102	33
Omit mouthwash after preventer	79	136	58
3. Spacer Condition			
Damaged valve	6	41	15
4. Device Not Available with Patient			
Preventer	120	262	46
Reliever	119	210	56
Long acting Reliever	55	94	59

Additional problems included the prescribing, labeling and dispensing of devices.
Conclusion: Simple problems that can lead to failure in asthmatic management may be undetected unless there is consistent and regular counseling and follow up of all patients and their carers.
Recommendation: A comprehensive and integrated asthma management programme can be achieved through:
1. Inclusion of practical management issues in asthma management guidelines
2. Management protocols which define responsibility for the 'who, what and how' of practical asthma management
3. Regular audit and research on practical management issues.
4. Public awareness

OF-01-045

Study on Activities of IL-4, IL-5 and Serum Ige Level in Patients with Allergic Asthma Remitting at Puberty

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Objective To evaluate the activities of IL-4 and IL-5 and the serum IgE level in patients with allergic asthma remitting at puberty. **Methods** All subjects were divided into four group, including A (allergic asthma remitting at puberty), B (asthma at stage of attack), C (asthma at stage of remission) and D (healthy subjects). The activities of IL-4, IL-5 and serum IgE levels in all subjects were measured by ELISA. **Results** (1) The activity of IL-5 in group A didn't significantly increase, being significantly lower than that in group B ($P<0.01$) and C ($P<0.05$). There wasn't obvious difference between group A and D. (2) The activity of IL-4 in group A was significantly lower than that in group B ($P<0.01$) , being not significantly different from group C and D ($P>0.05$). (3) Serum IgE level in group A was significantly lower than that in group B ($P<0.01$), being not significantly different from group C and D ($P>0.05$). **Conclusion** The activities of IL-4 and IL-5 in patients with allergic asthma remitting at puberty decreased significantly, and their serum IgE level decreased to a certain extent. These imply that IL-4, IL-5 and IgE play important roles in the mechanism of bronchial asthma.

OF-01-054

Changes of Eosinophil Cationic Protein and Soluble Interleukin-2 Receptor in Bronchial Asthma.

Jing Xu, jian Wang, Jiangping Zhang Department of Internal Respiratory, Tianjin Bailou Hospital, Tianjin China 300040

Objective In this study , an attempt was made to clarify the roles played by eosinophil cationic protein (ECP) and soluble interleukin-2 receptor (sIL-2R) in the pathogenic mechanism of asthma. **Methods** The fluorescent enzyme immunoassay (FEIA) and BA-ELISA were adopted to determine ECP and sIL-2R in sera from 30 healthy subjects, 61 patients with advanced bronchial asthma. ECP and sIL-2R in sera from 37 patients were determined continuously after treatment. **Results** The results showed that both the levels of ECP and sIL-2R in sera from the patients with bronchial asthma in the acute stage were significantly higher than those from the controls (P<0.01). Both the levels decreased significantly after treatment (P<0.01). **Conclusion** ECP is an important inflammatory medium for airway inflammation, and the level of ECP in serum is conductive to the judgment for the activity and the severity of asthmatic airway inflammation. The results indicated that a significant correlation exists between the activation of eosinophil and that of T-lymphocyte, as well as between the increased level of ECP and the activation of T-lymphocyte.

OF-01-055

CHARACTERISTICS OF INNER-CITY CHILDREN WITH RESPIRATORY SYMPTOMS ON ADMISSION TO AN EMERGENCY DEPARTMENT INTERVENTION IMPLICATIONS Lynda Thomas Goodfellow, Ed.D., RRT, Alice Demi RN, DNS, FAAN, Georgia State University, Atlanta, GA

Asthma is a chronic inflammatory disorder of the airways resulting in recurrent episodes of variable airflow obstruction, often reversible either spontaneously or with treatment. The purpose of this study was to describe the characteristics of inner-city children (ages 1-11) who were admitted to an emergency department (ED) with respiratory symptoms. The research question was "What percentage of children with respiratory symptoms indicative of asthma were diagnosed as having asthma and treated for asthma?" The sample consisted of all children who presented to the ED with a chief compliant of wheezing, cough, chest tightness, or shortness of breath (SOB) during a 6-week springtime period on 25 randomly selected shifts. These symptoms were chosen because they may indicate the presence of childhood asthma. A total of 582 medical records were reviewed. More males (57%) than females (43%) were admitted to the ED, the sample's mean age was 4.75 years. The chief compliant in rank order was 1. symptoms unrelated to a respiratory ailment (28%), 2. cough (22%), 3. fever (20%), 4. wheezing (14%), 5. cold, sore throat (6%), 6. shortness of breath (5%), 7. ear ache (3%) and 8. chest tightness (1%) / asthma (1%). The primary diagnoses recorded by physicians were: 1. wheezing (25%), 2. other related to the respiratory system (23%), 2. other not related to the respiratory system (23%), 4. upper respiratory tract infection (URI) (13%), 5. fever (8%), 6. asthma (7%) and 7. reactive airway disease (RAD) (1%). Ninety-four percent of the children (n = 547) had a history of asthma/wheezing. Ninety-three percent (n = 541) received an asthma handout upon discharge while only 3 children (.5%) were referred to the asthma clinic. The number of children given an asthma education and the number of children diagnosed with asthma are extremely incongruent. These findings suggest that these young children visiting an inner city ED for asthma symptoms have poorly controlled and poorly managed chronic asthma. Traditional ED care restricts its focus to therapy and treatment for acute exacerbations. Reimbursement issues influence the diagnosis and treatment of asthma in the acute care setting. There is a need to provide education in the school and in the home that focuses on early recognition of asthma symptoms and control, medication adherence, and identification of asthma triggers for young children. Few programs or interventions are targeted to the pre-school asthmatic population. As asthma management skills (self-care) and adherence improve, quality of life should also improve and number of ED visits and hospital admissions due to asthma related exacerbations should decrease.

OF-01-058

THE HEALTH STATUS OF ASTHMATIC CHILDREN, BEFORE AND AFTER THE IMPLEMENTATION OF A SCHOOL-BASED ASTHMA EDUCATION PROGRAM IN AN ATLANTA-CITY PUBLIC SCHOOL. Teresa M. Iatridis, MS, RRT, Lynda Thomas Goodfellow, Ed.D., RRT, Barbara Browning, MS, RN, Georgia State University Atlanta, Sharon Williams, M.Ed., RN, MLK Middle School, Atlanta, GA.

Asthma is one of the most common chronic illnesses among children. School-based asthma education programs have demonstrated reductions in asthma-related physician, emergency room, and hospital visits. Additionally, school-based asthma education programs have demonstrated improvements in asthma knowledge, asthma management skills, and medical treatment compliance. The purpose of this study was to obtain descriptive data to document the current health status and medical needs of the children participating in a school- based (Open Airways for Schools) program. This study investigated the following research questions, using descriptive research methodology: (1). What is the health status of asthmatic children, before and after the implementation of a school-based asthma education program, in an Atlanta City Public School, or is there a difference? (2). What percent of these asthmatic children are compliant with the current National Asthma Education and Prevention Program (NAEPP) guidelines for asthma prevention and management? The descriptive survey used in this study was created from four sources: (1). A review of the current NAEPP guidelines, (2). A review of publications of school-based asthma education programs, (3). A review of relevant literature involving the utilization of descriptive surveys to evaluate health status in asthmatic children, and (4). A review of existing school health surveys. The survey instrument contained questions addressing asthma history, asthma medications, recommended equipment, and asthma medical management/access. Prior to the initiation of a school-based asthma education program, the school nurse identified potential participants, using school health forms. Potential participants consisted of children, ages 8-11, with documented asthma on the school health form. A total of 16 children were identified. The parent/legal guardian of each asthmatic child was contacted to obtain permission for participation and completion of the survey instrument. All 16 children returned consent forms and completed the educational program. Upon completion, parents/legal guardians received a follow-up survey instrument. The final sample (n = 9) included those who returned before and after survey instruments (56%). NAEPP guideline compliance was reported in three areas: a). assessment and monitoring, b). routine pharmacologic therapy, and c). patient/family education and knowledge level. Sixty-seven percent reported possession of a peak flow meter. However, of those less than half reported peak flow meter daily use. Compliance was best (100%) for the use of a short acting Beta 2 Agonist. When considering asthma severity, none of the participants reported usage of the NAEPP guideline recommended medications. 89% knew the correct medications to administer for an acute asthma episode. 56% knew appropriate medications to administer for maintenance therapy. 33% reported having an asthma action plan. The findings show that the previously documented positive effects, of a school-based asthma education program, could not be duplicated within this study. However, this study has proven to be one of the first to document the health status of asthmatic children, within the Atlanta City Public School System, and evaluate the effects of a school-based asthma education program. Therefore, the information obtained within this study was essential and warrants future study.

OF-01-065

PEDIATRIC EMERGENCY DEPARTMENT OUTCOMES COMPARING LEVALBUTEROL VS. RACEMIC ALBUTEROL.

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Background: Pediatric asthma is a chronic condition of childhood with increasing prevalence. Emergency Department (ED) treatment of asthma constitutes a failure in outpatient management. Frequently, ED asthma treatment is unsuccessful and patients are admitted. Our ED data the past 5 years yielded an average admission rate of approximately 41%. The purpose of this study was to determine if levalbuterol resulted in improved clinical outcomes compared to racemic albuterol. Specifically, we sought to observe a decrease in admission rate. **Methods:** An a priori analysis powered at 80% (p-value <0.05) indicated a need to randomize 532 children to detect a 10% decrease in admission rate. Patients who consented for participation were randomized in a double-blind fashion to receive either 2.5 mg albuterol or 1.25 mg levalbuterol delivered by a high-density Nebutech (Salter Labs, Irvine, Ca.) nebulizer. We utilized our assessment-driven ED Asthma Carepath (ED-ACP) to control for treatment standardization between groups. Our ED-ACP standardizes assessments & therapy (oxygen, albuterol aerosols, corticosteroids) at prescribed intervals. Assessments and /or treatments were delivered every 20 minutes. Intensification of therapy was provided with either subcutaneous epinephrine (SQ Epi) injection (initially) and/or Ipratropium (during therapy). Treatment was discontinued when discharge criteria were met: good air exchange, mild / absent end expiratory wheezing, no accessory muscle usage, SpO2 > 93%, and respiratory rate<40/min. Patients were observed for one hour after their last treatment then discharged. Patients not meeting discharge criteria after 6 aerosols or 1 hour of continuous aerosols were admitted or transferred. A chronic asthma severity was assigned based on history, symptoms, and therapeutic drug usage. Fisher Exact Tests were used to compare race, gender, and administration of SC Epi & Ipratropium. A Pearson chi -square was used to compare chronic severity & admit vs. discharge status. Unpaired t-tests were used to compare age, ED LOS, initial SpO2 & aerosols delivered. Significance was set at $p < 0.05$. **Results:** This study randomized 552 children to treatment. Below are demographic and clinical outcome data reported as raw, mean (SD) or percentages with p-values.

Demographics	**Levalbuterol**	**Racemic Albuterol**	**p - Value**
Number	281	271	
Age	7.0 (4.0)	7.1 (4.2)	0.84
Caucasian Race (%)	12	15	0.27
Male Gender (%)	67	67	0.93
Severe Chronic Severity (%)	46	42	0.34
Outcome Data			
Admissions (%)	37	45	0.03
Aerosols delivered	3.8 (1.98)	4.1 (1.97)	0.05
LOS (in hours)	2.38 (0.84)	2.38 (0.86)	0.85
Administered SC Epi (%)	9	11	0.33
Administered Ipratropium (%)	23	30	0.10
Initial SpO2	94.8 (7.9)	95.5 (5.1)	0.25

Conclusion: Levalbuterol resulted in a clinical and statistical decrease in admission rate and treatments provided in our ED. An 8% decrease in hospital admission rate could result in a net savings of approximately $200,000 per year at our institution.

OF-01-073

ISSUES RELATED TO WHY FAMILIES USE THE EMERGENCY DEPARTMENT FOR ASTHMA TREATMENT. Teresa M. Iatridis, MS, RRT, Michelle Woods, American Lung Association of Georgia, Atlanta, GA, W. Michele White, Pharm.D., Michele Mindlin, M.U.P., Gloria Chen, RN, MBA, Georgia Department of Human Resources-Public Health Branch, James Bason, Ph.D., University of Georgia, Athens, GA, Lynda Thomas Goodfellow, Ed.D., RRT, Georgia State University, Atlanta, GA

Asthma is one of the most common chronic illnesses among children. It has been estimated that the treatment of asthma costs $6.2 billion per year in direct and indirect expenditures. Approximately 43% of this amount can be directly associated with emergency department (ED) visits, hospitalizations, and death. The purpose of this study was to begin to understand the many circumstances leading to the usage of the ED for treatment of asthma. The research question guiding the researchers was: What are the specific reasons why families use the ED for asthma treatment? A convenience sample (n=36) was obtained from participants using the ED at 5 participating hospitals. Participants were the parent/guardian of children with asthma, ages 0-17. After signed consent was obtained, participants were contacted 1-2 weeks after the ED visit for a phone interview regarding using the ED to treat their child's recent asthma episode. The findings can be classified into two categories. The first was *Issues Related to the Health Care Delivery System*. Sixty-seven percent reported that they were covered by a third party insurance provider and have their own regular physician. A majority of the participants (61%) utilized the ED for treatment of their child's asthma during non-business hours. The majority reported medication use, but only 3% reported using the recommended combination therapy of long and short acting beta agonists, inhaled corticosteriod, and stabilizer medication. Approximately 25% of the participants expressed concerns relating to medication costs when asked about their "biggest challenges" in daily asthma management. The second category found was *Issues Related to the Family's Ability to Manage Asthma Episodes*. Thirty-six percent reported doing nothing prior to bringing their child to the ED. Most respondents (72%) reported that the decision to bring their child to the ED for treatment was made by an adult living in the house. Less than half (47%) reported having a written asthma action plan for daily management of their child's asthma. Of those that did, only 14% described a plan that seemed appropriate, based on NIH asthma care guidelines. Finally, 58% reported that asthma often interferes with normal daily activities, yet when asked if they believe that the current treatment was working, 82% replied "yes". From the information obtained, it appears that asthma-related ED visits could possibly be reduced through further education and intervention planning. The proper education regarding disease management, recognition of signs and symptoms, medication administration, and expected outcomes would be beneficial to the patient, their families, and their health care providers.

This study was supported by the Georgia Department of Human Resources, the American Lung Association of Georgia, and the WG Raoul Foundation. OF-01-078

COMPUTER BASED INTERACTIVE EDUCATION PROGRAMS FOR HOSPITALIZED CHILDREN WITH ASTHMA AND SICKLE CELL DISEASE. M. Kinlow, RRT, Hughes Spalding Children's Hospital, A. Hazzard, P.h.D., Emory University School of Medicine, F. Adams, RRT, Hughes Spalding Children's Hospital, B.Batts, MPH, RRT, Hughes Spalding Children's Hospital.

Introduction: STARBRIGHT World is an innovative computer network for hospitalized children that provides interactive health education, as well as opportunities to meet on-line with children in other hospitals. **Purpose:** This study examined whether hospitalized children who use STARBRIGHT World would demonstrate greater increases in knowledge of their chronic illness when compared to control patients who were provided standard care. **Subjects:** One hundred and ten children participated in the study; sixty in the control group and fifty in the treatment group. Sixty-three children were diagnosed with asthma and 47 had sickle cell disease (SCD). Most (98%) were African-American, and participants ranged in age from 8 to 18. **Design:** This study utilized a pre-post treatment- control group experimental design, with children randomly assigned to experimental group according to time of hospitalization. Children in both groups received verbal health education from respiratory therapy (RT) staff as part of routine hospital care. Children in the treatment group participated in one to three sessions of STARBRIGHT World use, guided by a research staff member, several of whom were RTs. Features of STARBRIGHT World that were used included health education activities, videoconferencing, and chat rooms, as well as recreational features. For children with SCD, Sickle Cell Slime-O-Rama, an interactive educational "game show" developed by STARBRIGHT Foundation, was the primary educational activity; for children with asthma, several websites accessed via STARBRIGHT World provided the primary disease and treatment-related information. Previously validated knowledge questionnaires (for SCD and asthma respectively) were administered to all subjects after admission and before discharge and a questionnaire assessing children's subjective responses to hospital activities was administered at post-testing. **Results:** Four repeated measures analyses of variance were conducted on knowledge scores according to disease-age subgroups. In each subgroup, treatment children's knowledge score gains were greater than those of control children; these differences approached statistical significance (p=.06) for teens with asthma. Ninety-six percent of treatment subjects rated themselves as liking STARBRIGHT World " very much", the highest rating on a 4-0point scale. **Conclusions:** STARBRIGHT World shows promise as a health education tool which RTs and other healthcare professionals can utilize to increase children's disease and treatment-related knowledge. OF-01-086

ARE SELF-REPORTED SURVEY TOOLS ADEQUATE FOR SCREENING OF ASTHMA IN ELEMENTARY SCHOOLS? **Mike Trevino, RRT; Sharon Trongaard, RRT; Denise Rebel, RRT; Melody Rodriquez, MA; Richard Gilder, RN, CNOR; Gary Weinstein, MD, Presbyterian Hospital of Dallas, Dallas, TX.**

BACKGROUND: The health of children is a top priority for both legislatures and school districts statewide. Hearing, vision, and spinal screenings are mandated by the Texas legislature for school-aged children and are associated with prevalence rates of 2.3%, 8.4% and 2.2%, respectively. The Texas Department of Health now identifies asthma as the fifth leading reason for visits to school-based health centers. This being the case, it seems appropriate to focus efforts towards asthma surveillance in school-aged children. Asthma has traditionally been assessed through self-reported survey methods in this population. However, this method may be inadequate to effectively capture children that may benefit from asthma intervention. Pulmonary Function Tests (PFTs) may offer a significant contribution to school-based assessment of asthma. **PURPOSE:** The purpose of this study was to determine if a self-reported screening tool would effectively identify children with asthma or if this screening tool should be complimented with Pulmonary Function Testing. **METHODS:** Following approval from the School District, a short YES/NO questionnaire, in Spanish and English, was distributed in the school enrollment packets in August 2000. Surveys were distributed for students in grades one through six in five schools in a large metropolitan, economically depressed geographic area (avg. 77% school lunch program participation). The questionnaire was designed to identify asthma and allergy symptoms and included a permission slip to have PFT Studies performed. Questions focused on coughing/wheezing, and/or shortness of breath related to disease-specific variables. Respiratory Therapists performed pulmonary Function Tests in the schools using a PB-100 hand-held spirometry system. **RESULTS:** 3694 quesuonnaires were distributed, 1696 (46%) were returned and N=1490 met criteria for inclusion (ability to produce reliable PFT) in the study. The demographics for this population were; 54% were Hispanic, 26% African American, 19% Caucasian, and 1% other. The mean age was 8.5 years. 51% were male, 49% female. To the question "Have you ever been told your child has asthma or reactive airway disease?" 22.6% responded "YES "and of these, 78.7% had abnormal PFTs (<80% predicted values). Conversely, 77.4% responded "NO" and 29.8% of this group had abnormal test results (these would have gone unrecognized with a survey method only). Chi-square tests were performed to examine the relationship between normal/abnormal PFTs and disease- related variables. All findings were statistically significant at the $p=.05$ level.

Variable	FEV1 Norm/Ab	Pearson's Chi-Square	Sig	FEF25-75 Norm/Ab	Pearson's Chi-Square	Sig
Sudden Episodes		24.945	.000		30.633	.000
Night Time Symptoms		17.978	.000		19.904	.000
Seasonal Episodes		25.318	.000		32.195	.000
Chest Colds		26.814	.000		25.938	.000
Environmental Exposures		12.694	.000		19.072	.000
Physical Activity		21.091	.000		23.673	.000

CONCLUSION: Self-reporting survey tools may be inadequate to effectively capture children that may benefit from asthma intervention. Pulmonary Function Studies should be included as a vital component of school-based asthma surveillance programs. OF-01-082

ASTHMA MANAGEMENT IN THE PEDIATRIC INTENSIVE CARE UNIT: CASE COMPARISONS. Theresa Ryan Schultz BA, RRT, RN, Shawn Colborn, AS, RRT, Roberta Hales BS, RRT, Richard Lin MD, Andrew T. Costarino MD. The Children's Hospital of Philadelphia, Philadelphia, PA.

Introduction: Asthma continues to be a leading cause of admission to the pediatric inpatient setting. In an effort to standardize the approach to care, a clinical pathway developed and implemented by a multidisciplinary team at our institution resulted in a decreased length of stay with no increase in the re-admission rate[1]. This in-patient protocol includes the care of mild, moderate and severe asthmatics in our Asthma Care Unit. Because our experience indicates that approximately 10% of the patients admitted for asthma will require admission to the Intensive Care Unit (ICU), we extended the asthma protocol to include management of the critically ill patient. This pathway guides us in the management of terbutaline, heliox, mechanical ventilation and Isoflurane. **Methods:** A retrospective review of admitted ICU patients requiring mechanical ventilation over a two-year period was done. Compliance with established protocol, determined category as "pathway" or "non-pathway" patient. Vital signs, Pediatric Risk of Mortality (PRISM III), FiO_2, maximum dose of continuous ventolin, steroids and terbutaline, mechanical ventilation, heliox and Isoflurane hours were evaluated as well as ICU and hospital length of stay (LOS). **Results:** 10 patients were reviewed, 5 male and 5 female, average age 6.6 years (range 35 mos. to 14 yrs.). Of these patients, 70% were managed in compliance with the critical care pathway.

	Pathway	Non-Pathway
Prism III 12/24	7/8	4/4
LOS (ICU days)	4	2
LOS (hospital days)	5.6	4
CV max. dose (mg/kg/hr.)	1.2	0.7
Steroid max dose (mg/kg)	1.3	1
Terbutaline max. dose (mcg/kg/min.)	2.2	0
Heliox hours	1.4	0
Mechanical ventilation hours	32.1	12.25
Isoflurane hours	19.25	0
$FiO_2 > 0.60$ (hours)	9.1	1

mean values presented (n=10)

Conclusion: Although the subjective evaluation of this pathway was positive, our retrospective review of the data indicates that a positive difference in outcome, LOS (ICU or hospital), between pathway and non-pathway critical care asthma patients was not realized. **Discussion:** The difference in Prism III and care requirements; $FiO_2 > 0.60$, terbutaline maximum dose, heliox, mechanical ventilation and Isoflurane hours suggest a disparity regarding severity of illness between groups. In addition, the possibility exists that contamination of the non-treatment group occurred, since this review includes patients within the same period of time. Further evaluation of this protocol would benefit from a prospective randomized approach to implementation, as well as a disease specific indicator concerning severity of illness.

Welsh KM, Napoli L., and Magnusson M. Asthma Clinical Pathway: An Interdisciplinary Approach to Implementation in the Inpatient Setting. Pediatric Nursing 1999; 25: 79-87. OF-01-120

AN ASSESSMENT OF A RESPIRATORY THERAPIST-DIRECTED ASTHMA PROGRAM

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Background: For optimal management of asthma, The National Heart, Lung, and Blood Institute (NHLBI) has established *Guidelines for the Diagnosis and Management of Asthma*. These guidelines suggest that when asthma is properly managed, emergency room visits, unscheduled doctors visits, hospitalizations, and school or work days missed due to asthma are decreased. The Asthma Center is a respiratory therapist-directed asthma education and treatment program designed to adhere to the NHLBI guidelines. Objective: The objective of this study was to determine if participants in the Asthma Center improve spirometric test results and decrease frequency of symptoms, emergency room visits, hospitalizations, unscheduled doctors visits and school or work days missed due to asthma. Design, Sample, and Procedures: This was a retrospective study comparing one year of historical data and initial spirometric data from 82 new participants in the Asthma Center with the same data after they had been enrolled in the program for at least one year. The historical data was collected from medical records and included number of emergency room visits, hospitalizations, unscheduled doctors visits, school or work days missed due to asthma, use of spacer and peak flow meter, and the frequency of symptoms (coughing, wheezing, shortness of breath, chest tightness, and sinus infection). The spirometric data included peak expiratory flow (PEF), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced expiratory flow between 25% and 75% of the FVC (FEF25-75%). Data were analyzed using a one sample t-test and chi square tests with statistical significance defined as $p < 0.05$. Results: There were statistically significant ($p<0.05$) improvements in all spirometric tests and symptoms. FVC improved by 11%; FEV1 improved by 18%; PEF improved by 27%, and FEF25%-75% improved by 31%. Of the patients who complained of asthma-related symptoms, 76% reported improvement in coughing; 73% reported improvement in wheezing; 85% reported improvement in shortness of breath; 80% reported improvement in chest tightness; 51% reported improvement in their sinus problems. While there were no statistically significant differences between the number of emergency room visits or hospitalizations, there were statistically significant ($p<0.05$) decreases in the number of unscheduled doctors visits (3.19 ± 4.6) and days of school or work lost (1.95 ± 3.3) due to asthma. Prior to the initial visit only 1.2% used a peak flow meter and 15.7% used a spacer. After a year enrolled in the Asthma Center 97.6% used a peak flow meter and 100% used a spacer. Conclusion: A respiratory therapist-directed asthma management program designed to adhere to the NHLBI guidelines for optimal management of asthma can improve spirometric measurements and decrease the frequency of asthma-related symptoms, the number of unscheduled doctors visits, and the number of school or work days missed due to asthma.

OF-01-135

DETECTION OF OCCULT EXERCISE INDUCED ASTHMA IN COLLEGIATE ATHLETES FOLLOWING A SIX MINUTE FREE RUN

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Research Question: What is the prevalence of exercise-induced asthma in athletes who play intercollegiate sports? Data from other researchers (Kukafka et al. and Harries) suggest that the prevalence may range from 9% in high school athletes to 20% in (British) Olympic athletes, our small study investigated the prevalence in a group of intercollegiate athletes on an urban campus.

Methods & Materials: Athletic trainers and coaches recruited volunteers from male and female inter-collegiate athletes who play basketball, soccer and track. Volunteers were screened and exclusion criteria included being a current respiratory tract infection, a diagnosed history of adolescent or adult asthma or exercise-induced asthma, smoking and clinical evidence of a respiratory infection. Participants signed an informed consent and then completed a screening survey regarding their personal and family medical history. Baseline and subsequent spirometry was performed using ATS criteria for calibration and performance validity using a Renaissance (Puritan-Bennett Corp., Lenexa, KS). A resting EKG (KoKo Rhythm, Pulmonary Data Services, Louisville, CO), tympanic body temperature, and pulse rate were taken. The ambient temperature and relative humidity of the gymnasium was recorded for each day of testing.

The participants were required to run for six minutes in a gymnasium at a speed that would produce a heart rate of approximately 80% of their predicted maximal heart rate (220 – age X 0.80). Immediately after the run the participants were seated without a cool down and a post-exercise spirometry, heart rate and tympanic temperature were taken. Subsequent spirometric values were taken in the five-minute intervals up to 30 minutes post exercise.

The University's institutional review board for human research (IRB) approved the study.

Results: Twelve intercollegiate athletes met the inclusion criteria and signed informed consent. The average age was 19 y/o (range 18 –21) with an average height of 67.4 inches (the average male was 70 inches while the average female was 66 inches) and weight of 150 lbs. (the average male was 32 lbs. heavier than his female counterpart). There were no significant differences in tympanic body temperature (96.3°F), blood pressure (116/72 male vs. 116/69.4 female) or resting heart rate (71.2 male vs. 72.7 female) among the participants. Of the 12 participants, 5 male and 7 female, two had a 15% or greater drop in their FEV1% (FEV1/FVC). Both participants experienced an 18% and 15% decline in their FEV1% at 15 minutes post running and both of these participants recovered to within 6% of their baseline FEV1% by thirty minutes. Participants were between 18 and 21 years. There were no significant differences in pre and post tympanic (body) temperature or in pulse rate. As might be expected, there were no complaints of shortness of breath, wheezing or chest tightness. Ambient conditions experienced a relative humidity of $32.0\% \pm 7.0\%$ and a temperature which averaged 73.2 °F (71.6° F to 76.1° F).

Conclusion: Our limited data suggests that a number of inter-collegiate athletes may have undiagnosed or occult exercised-induced asthma and that further study is necessary to determine the prevalence of EIA in inter-collegiate athletes.

OF-01-145

THE USE OF PEEP IN A MECHANICALLY VENTILATED PEDIATRIC ASTHMATIC: A CASE REPORT.

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Backround: Approximately ten percent of patients admitted, to our institution with asthma, require intensive care. Recognizing the need for a systematic approach to the management of these patients, a critical care asthma pathway was developed, including the use of continuous albuterol, intravenous (IV) terbutaline, heliox therapy, inhaled isoflurane and guidelines for the management of positive pressure mechanical ventilation. The asthma patient requiring positive pressure mechanical ventilation presents a unique challenge. The literature suggests that the application of PEEP may reduce the work of breathing in patients with severe airflow obstruction either during the weaning phase from mechanical ventilation or when ventilatory assistance is required for respiratory muscle fatigue (1). Our protocol recommends frequent assessment of auto-PEEP and guidelines for the application of mechanical PEEP (extrinsic). Extrinsic PEEP is set at zero in the chemically paralyzed patient and at the level of measured auto-PEEP in the spontaneously breathing patient.

Introduction: This 16-kg female, with a history of asthma, was admitted to an outlying Emergency Department in severe respiratory distress. She presented with altered mental status, minimal airflow movement with inspiratory and expiratory wheezing upon auscultation, cyanosis with a SpO_2 86% in room air, tachypnic to 44 breaths per minute, tachycardic to 200 beats per minute, nasal flaring, and substernal retractions. The patient received subcutaneous epinephrine twice, IV magnesium sulfate, solumedrol, terbutaline, continuous inhaled albuterol and intermittent inhaled atrovent. With minimal response to therapy and evidence of a primary respiratory acidosis, pH of 7.0 and $PaCO_2$ 125 torr, the patient was intubated and transferred to our institution.

Upon arrival to our Pediatric Intensive Care Unit, she was reintubated with a 5.0 cuffed endotracheal tube and ventilated with Synchronized Intermittent Mandatory Ventilation (SIMV) mode, mechanical frequency 15, Tidal Volume (V_T) 130ml, PEEP 0 cmH_2O, Inspiratory Time (T_I) .75seconds, FiO_2 1.0; resultant peak pressure (PIP) of 43cmH_2O. The chest radiograph, at this time indicated, hyperinflation with a right lower lobe atelectasis. As respiratory acidosis persisted (maximum $PaCO_2$ of 191 torr), care was escalated in accordance with the critical care asthma pathway to include continuous IV terbutaline, intermittent IV steroids, ketamine, pancuronium, magnesium and calcium, isoflurane inhalation and albuterol via in-line metered dose inhaler with a spacer device. After sixteen hours of mechanical ventilation, the patient's condition stabilized and the neuromuscular blockade was discontinued. Measured auto-PEEP was 14 cm H_2O and arterial blood gas analysis indicated pH 7.34, PCO_2 57 torr, PO_2 98 torr, HCO_3 30 base excess 3.8 on SIMV, frequency 24, V_T 180ml, PEEP 3 cmH_2O, T_I .6seconds, FiO_2 .45 and PIP 50-55cmH_2O. Frequent assessment of auto-PEEP was done utilizing a Bicore CP100 to determine best PEEP in this now spontaneously breathing patient.

PEEP ($cm H_2O$)	PIP ($cm H_2O$)	Exhaled V_T (ml)	Airway Resistance (cm/L/sec)	Lung Compliance (ml/$cm H_2O$)
3	44	129	52	9
5	43	137	54	10
8	39	148	55	15
10	37	155	48	20
12	37	160	45	30
14	37	154	41	45

Because meeting auto-PEEP yielded best lung compliance and airway resistance, while maintaining adequate oxygenation and ventilation, with a subjective assessment consistent with improved work of breathing in this awake, spontaneously breathing patient, 14 cm H_2O of mechanical PEEP was continued. Assessments of auto-PEEP continued and decrements in applied mechanical PEEP were adjusted accordingly. This patient was successfully weaned to extubation within 12 hours.

Discussion: Application of mechanical PEEP at the level matching measured auto-PEEP seemed beneficial in the management of this pediatric asthma patient requiring positive pressure mechanical ventilation. The use of extrinsic PEEP and timing of its application, deserves further investigation.

1. Gottfried SB, Rossi A, Milic-Emili J. Dynamic Hyperinflation, Intrinsic PEEP and the Mechanically Ventilated Patient. Intensive Critical Care Digest 1986; 5:30-3

OF-01-157

PILOT SURVEY TO DETERMINE POTENTIAL INDOOR TRIGGERS OF INNER-CITY CHILDREN WITH ASTHMA

Marsha A. Rogers CRT, Robert Chatburn RRT, FAARC, Timothy R. Myers BS, RRT. Rainbow Babies and Children's Hospital, Cleveland, OH.

Introduction: Asthma is a chronic inflammatory airway disease that affects approximately 5 million children in the United States. While asthma is the most common discharge diagnosis in pediatric hospitals, it also accounts for significant daily morbidity. Children with asthma tend to have increased airway sensitivity to a variety of stimuli, such as allergens, irritants, and viruses. Often, an offending environmental trigger can in large part be located within the patient's own home. While asthmatic families appeared to have a solid foundation of knowledge in relation to the disease and medications prescribed, this knowledge base appears inadequate in identifying causative triggers (Resp Care 1998, 43(10): 844). Asthma trigger education could potentially be streamlined to specific, common indoor inner-city allergens if they could be identified. The purpose of this study was to identify specific indoor asthma triggers or trigger categories present in inner-city homes. **Methods**: Over a 3-month period (May-August), all family caregivers of patients admitted to our Asthma Care Unit (ACU) were asked to complete a questionnaire to identify indoor asthma triggers that were present in their place of residence. The questionnaire was designed to identify allergens by category. Second-hand Smoke, Dust Mites, Fumes, Pets, Pests and Mold. Each main trigger category had specific allergens and some potential preventative or causative behaviors. **Results:** A total of 113 children and their families participated in this descriptive pilot study on Inner-city indoor asthma triggers. Presence of indoor triggers identified by families ranged from 0-11 triggers (out of a possible 22 listed). The average number of identified indoor triggers per home was 5.2. The five most prevalent sources of potential triggers in this cohort of patients were: carpeting in child's bedroom (76.1%), presence of gas stove (72.6%), carpeting in "television" room (63.7%), presence of stuffed animals in the child's bedroom (60.2%), and exposure to second-hand smoke (32.7%). On a preventative note, the following percentages of families reported potential positive trigger remediation behaviors: washing of bed linens >1 time/week (87%), vacuuming of carpets >2 times/week (78.8%), households reporting no smokers (76.6%) and presence of dust proof casings on pillows and mattresses (25.7%). In the tables below are results reported for presence of triggers by category (averages) and identified triggers per household (percentages).

Identified Triggers by Category

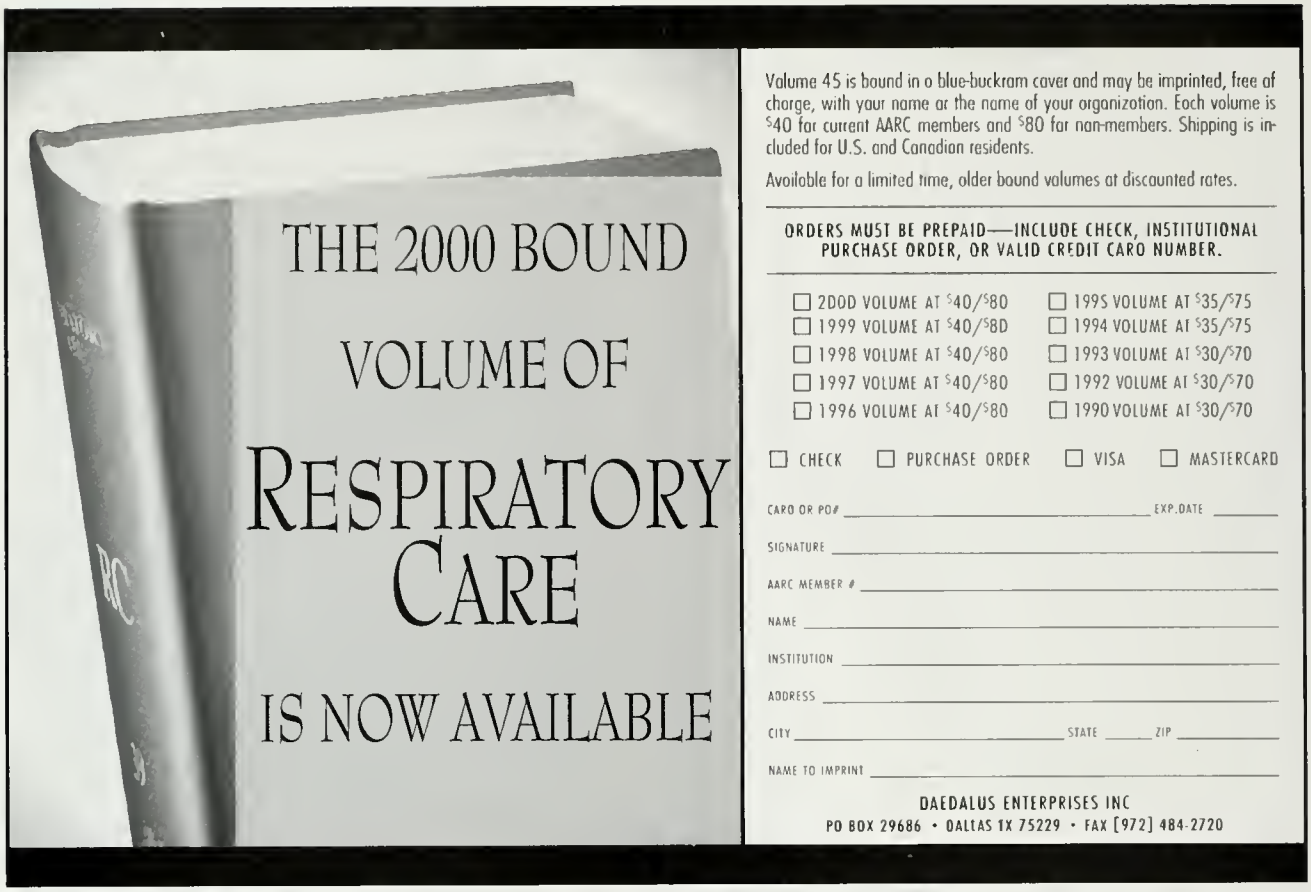
Dust Mites	2.28	Pets	1.18
Fumes	1.65	Pests	1.09
Second-hand smoke	1.36	Molds	0.50

Indoor Triggers Present per Household

None	2 (1.8%)	Six	22 (19.5%)
One	2 (1.8%)	Seven	15 (13.3%)
Two	4 (3.5%)	Eight	7 (6.2%)
Three	10 (8.6%)	Nine	2 (1.8%)
Four	24 (21.2%)	Ten	1 (0.9%)
Five	22 (19.5%)	Eleven	2 (1.8%)

Conclusion: Most inner-city asthmatic families that participated in this study had exposure to significant amounts of indoor allergens in their own homes.

OF-01-168



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Does Asthma Education Improve Outcomes in Hospitalized Asthma Patients?

William F. Bria, M.D., Diane White, RRT
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INTRODUCTION: Asthma is the most common chronic respiratory condition in the United States today. Asthma statistics and asthma related deaths continuing to rise each year. With this in mind, the University of Michigan Health System (UMHS) implemented an Adult Asthma Education Program in February 2001; to measure the impact of an asthma disease management education program (ADM) has on improving outcomes in hospitalized asthma patients.
OBJECTIVE: To improve patient education, decrease health resource utilization, and to offer the unique opportunity for medical students to participate directly with chronic disease management under the guidance of respiratory care and attending physician staff. The model of this inpatient patient education program was targeted to intervene with the patient at the "teachable moment" i.e.: hospitalization where upon the patient has recognized that their current asthma management practices have failed
METHODS: The UMHS asthma education program consists of a one-hour education intervention utilizing third and fourth year medical students as the primary patient educators. Patients complete initial and follow-up self reported surveys identifying previous asthma management experience, missed days from work and school, overall health resource utilization, and overall patient satisfaction with asthma management. The results of the 34 patients we have educated to date are listed in the table below.
RESULTS:

Parameter	Initial	3 weeks	3 months
Prior asthma managment	4	34	
Hospitalizations	69	0	
Emergency room visits	74	1	
Unscheduled office visits	50	2	
Days spent ill	190	60	
Days out of work/school	361	122	
Asthma control-poor	12	0	
Patient satisfaction with Asthma Management - very satisfied		67%	

CONCLUSION: As we continue to obtain data, we conclude that patient education of chronic disease management with the inclusion of written patient self-management plans can impact on improved patient outcomes and satisfaction, decrease in health resource utilization, and provide a valuable learning experience for medical students on disease management through the utilization of patient education and implementation of patient self-management plans. We found in this study alone, nearly ninety percent of all the patients had no written asthma management or action plan prior to the hospital asthma education intervention. Further study into this subject could enhance the quality of life of other asthmatics through the implementation of hospitalized asthma education programs with written patient self-management plans utilizing medical students as primary patient educators at a "teachable moment" when a patient has realized that current asthma management has failed.

OF-01-228

ASTHMA EDUCATION SESSIONS PRESENED DURING A SUMMER CAMP EXPERIENCE Cathy Walston, BS, RRT, RPFT, Children's Hospital Medical Center, Cincinnati, Ohio

The number one reason for hospital admissions and absenteeism in schools in the pediatric population is due to respiratory diseases. A significant number of these respiratory illnesses are due to asthma. Each year, Children's Hospital Medical Center (CHMC) and the American Lung Association-Southwest Ohio Branch (ALA-SWOB) cosponsor a camp for children with asthma. While at camp, the children participate in traditional camp activities as well as asthma education sessions. These education sessions are based on the National Institutes of Health (NIH) Guidelines for Asthma Education. We wanted to know if participants increased their knowledge about asthma during the camp education sessions. A five-part program was presented Sunday through Thursday mornings. These sessions included information about basic anatomy and physiology, asthma triggers early warning signals of an asthma attack, medications, and self-management and relaxation techniques. Campers were divided into three groups based on age. For the purposes of this project, only the campers of the age seven and eight year old grouping were evaluated. There were eighteen participants in this group. Fourteen children of this group were boys. Twelve or 75% of this group were first time campers. Parental permission was obtained for the campers to participate in the program. Participants were given a twenty question multiple-choice test before the first educational session and after the last session. The results of the pre and posttest were compared using a two-tailed critical *t* value statistical analysis. When comparing the results of the pre education sessions to the post education sessions, there was not a statistically significant improvement in the knowledge gained by the campers. However, there was a trend for the campers to have an increase in knowledge about their asthma.

OF-01-256

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COMPARISON OF POINT OF CARE LACTATE ANALYSIS TO LABORATORY ANALYSIS IN PEDIATRIC PATIENTS WITH CONGENITAL HEART DISEASE

Jenni L. Raake, BS, RRT, Jerri McNamara, BA, BS, CCP, Donna Kinnemeyer, MLT, Steven Schwartz, MD, David Nelson, MD, PhD
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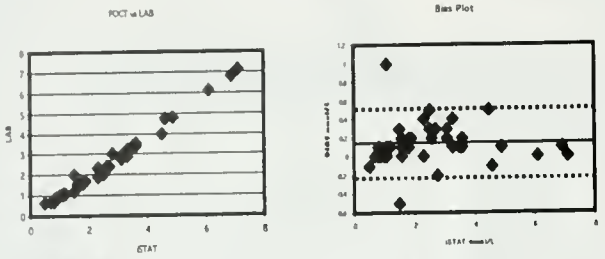
Intro: Lactic acid production from anaerobic metabolism can occur in hypoxia, cardiogenic and septic shock, heart failure, hypoxia, respiratory insufficiency and hematologic disorders. Serum lactate analysis is usually performed in the central laboratory, taking 45 – 60 minutes. We evaluated the iSTAT CG4+ Lactate and Blood Gas Cartridge (I-STAT Corporation, East Windsor, NJ) in order to determine the correlation with centralized laboratory testing. **Methods:** Split sample testing was performed on 45 samples from 5 patients with congenital heart defects. The blood was analyzed using the iSTAT CG4+ cartridge and analyzer, and the matched sample was shipped to the central laboratory on ice for analysis on the Vitros 950 Chemistry Analyzer (Ortho-Clinical Diagnostics, Raritan, NJ). Linear regression was used to determine correlation, slope, and intercept values. Bias and precision were determined using the technique described by Bland and Altman. **Results:** Correlation coefficient (r value) was 0.99, slope was 0.986, intercept was –0.1, ($p<0.001$). Bias was 0.1 mmol/L, while precision was 0.22. Results from the iSTAT CG4+ cartridge were available in two minutes. A cost comparison that included staff time revealed that laboratory costs were $7.50 while bedside testing costs were $5.79.



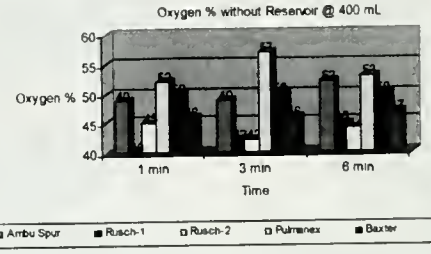
Conclusions: We found bedside lactate measurements using the iSTAT CG4+ cartridge to be rapid and cost effective, with good correlation to laboratory analysis.

OF-01-027

PEDIATRIC MANUAL RESUSCITATION DEVICES FUNCTION

C. Mettler, J. Sowders, J. Koss, MS, RRT, FAARC & D. Cullen, EdD, RRT, FAARC,
Respiratory Therapy, School of Allied Health Sciences, Indiana University.

Background: We evaluated six different pediatric manual resuscitation bags. The bags used were made by Ambu, Rusch (2), Pulmonex, Baxter and Allegiance. The research was conducted in order to determine function and the fractional delivered oxygen concentration (F_DO_2) with a 100% O_2 source and to determine function with varying tidal volume delivery. Methodology: The oxygen was given via a calibrated flowmeter at 15L/min and measured with a Hudson-RCI 5590 calibrated analyzer for every trial according to ASTM F-920 and ISO 8382 which specify an outcome of F_DO_2 of > or = to 85% with attachments and > or = to 40% without attachments for each device. Four 6-minute trials for every bag were conducted with a lung simulator. Two of the trials were done with a tidal volume (V_T) of 150 mL and the other two trials used a V_T of 400 mL. Each trial was done with and without an oxygen reservoir system. Rate and I:E ratio were checked via a stopwatch and chronometer. Results: The use of a reservoir system increased the F_DO_2 of the bag and decreased the time required for the bags to reach a higher F_DO_2. Results from 1-6 minutes varied from 79% to 100% at a tidal volume of 150 mL with a reservoir, and from 88% to 100% at a tidal volume of 400 mL with a reservoir. Results from 1-6 minutes varied from 42% to 79% at a tidal volume of 150 mL without a reservoir, and from 40% to 57% at a tidal volume of 400 mL without a reservoir (see figure). Experience: Therapists should be aware that a higher F_DO_2 can be delivered with a reservoir and larger tidal volume as opposed to a smaller tidal volume and that devices may require 4-5 minutes to achieve their Maximum F_DO_2. Conclusions: Devices should be independently tested to secure the best device for the pediatric patient independent of cost.



OF-01-028

OUTCOMES OF PULMONARY HEMORRHAGE SYNDROMES (PHS) IN THE PEDIATRIC INTENSIVE CARE UNIT (PICU)

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BACKGROUND AND OBJECTIVE: Pulmonary hemorrhage in the PICU is diagnosed more frequently than in past years and is caused by multiple etiologies. We sought to determine the outcomes in patients with PHS presenting with respiratory failure, particularly when analyzed in terms of the type of bleeding on presentation.

METHODS: We retrospectively evaluated outcomes of all pediatric patients aged 10 days to 16 years admitted to our PICU with acute PHS and respiratory failure from January 1995 through December 2000. We assessed each patient for type of hemorrhage [diffuse alveolar (DAH) versus localized airway/parenchymal (LAP)]. This was determined on admission by radiography and bronchoscopy. Outcomes measured included days of mechanical ventilation (MV), need for high frequency oscillation (HFO), days of hospital stay (HD), recurrence of bleeding (R), development of multi-organ failure (MOF), need for surgical intervention (S), need for home care (HC), and survival.

RESULTS

		Outcome Variable							
	N	HD	MV(d)	%HFO	%MFO	%R	%S	%HC	%survival
DAH	12	27	11	33	17	17	8	25	100
LAP	12	137	64	25	42	83	67	100	67
"p" Value		05	.06	.62	.18	.001	.003	.001	.001

There were no significant differences between groups in mean airway pressure, need for inhaled nitric oxide, or length of PICU stay. There was a significant difference in the frequency of recurrent pulmonary bleeding in the LAP group, many of whom had congenital heart disease or pulmonary vascular lesions.

CONCLUSIONS: We conclude that DAH with respiratory failure have substantially better outcomes than LAH presenting to PICU. We speculate that these differences may be related to underlying, poorly responsive lesions resulting in recurrent PHS. Multiple early interventions may be necessary in this group of patients.

OF-01-059

Comparison of Two Methods to Deliver Subambient Oxygen to Infants with Hypoplastic Left Hearts Via an Oxyhood

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Introduction: Survival of infants with hypoplastic left heart syndrome (HLHS) is dependent upon achieving several therapeutic goals. One goal is to maintain a balance between systemic and pulmonary blood flow. This can be achieved using subambient concentrations of oxygen (15-20%). Subambient oxygen concentrations can be delivered by adding a measured flow of nitrogen to the inhaled gas (bleed-in technique). Some children with HLHS require mechanical ventilation strictly for the precise delivery of subambient oxygen to meet the aforementioned goal. Theoretically, mechanical ventilation could be avoided by administering subambient oxygen with a hood setup. Cardiology and Cardiothoracic Surgery at our institution desire subambient oxygen stability in 5-10 minutes after manipulation. The purpose of this study was to compare the efficacy of delivering subambient oxygen concentrations via a high-pressure system previous described (Respir Care 2000; 45(8):1009) vs. a traditional bleed in system. **Methods:** Five Teledyne T-190 (Teledyne Brown Engineering) oxygen analyzers were calibrated per manufacturer's specifications prior to use (analyzer accuracy for subambient oxygen has been previously documented in Resp Care. 1999;44.1226). We placed an infant resuscitation manikin in a 12"x12"x12" oxygen hood (Nova Health Systems, Blackwood, NJ) for simulation purposes. Oxygen analysis from five sites in the hood would be conducted simultaneously. Analyzer #1 was placed at the humidifier, #2 at the top of the hood, #3 midway between top and bottom, #4 at mouth level, and #5 on the bottom of the hood. Analyzer locations were the same for both systems. Blender flow was set at our standard rate of 12 L/m. When assessing the bleed-in system, flow from the oxygen blender was decrease as the nitrogen flow was bled-in to achieve a similar maximal flow of 12 L/m. Starting with a FiO_2 of 21%, the FiO_2 was decreased to clinical subambient levels in increments of 1-4% (e.g. 21% to 17% = 4% change). Time (in seconds) was recorded from stability of analyzer #1 to a steady state on the other analyzers or a maximum time constraint of ten minutes as a test stop point. **Results:** Each analyzer site (Top, Mid, Mouth & Bottom) had the following number of measurements for clinically relevant changes in FiO_2 percentage (6 measurements at 1% change, 5 measurements at 2% change, 4 measurements at 3% change, and 3 measurements at 4% change). The bleed-in system was terminated by time constraint 79% (57 out of 72) of all measurements, and in 77% (14 out of 18) of the measurements made at mouth level. The high-pressure system was terminated 11% (8 out of 72) of all measurements, and in 0% (0 out of 18) of the measurements made at mouth level. When subambient oxygen was analyzed at mouth level, the high-pressure system on average was 4.45 faster to stability (18 measurements of 1-4% drop). Data below are average times (min:sec) for all measurements to achieve various drops in FiO_2.

	1% Drop	2% Drop	3% Drop	4% Drop
Bleed-in	8:40	9:44	9:49	10:00*
High Pressure	4:44	4:40	6:10	7:55
Difference	3:56	5:04	3:39	2:05

**denotes termination*

Conclusions: Delivery of subambient oxygen with a high-pressure system results in quicker stabilization of end-point FiO_2 compared to the traditional bleed-in method.

OF-01-064

PCO_2 AND PO_2 VARIABILITY IN CAPILLARY TUBE BLOOD DUE TO HANDLING TECHNIQUES

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Neonatal patients who have compromised ventilation and lack arterial lines are typically managed on the basis of capillary blood gas analysis. Capillary blood gas samples are routinely in the 80 to 175 micro-liter range. Many blood gas analyzers have the capacity to measure micro-samples in the order of 30 micro-liters. To prevent this small amount of blood from clotting before analysis, therapists typically agitate capillary samples. We studied the effects of different agitation techniques on $PcCO_2$ and PcO_2 We took left over arterial blood gas blood taken from adults and analyzed the blood to establish a baseline. We then used that blood to fill capillary tubes and subjected full tubes (150 to 165 micro-liters) and micro samples (30± micro-liters) to two treatments. One sample was twirled, i.e. it was rotated about the long axis of the capillary tube prior to analysis for 30 seconds. A second sample was 'rocked' about the center of the tube in approximately 60 degree arc, allowing the blood to flow to the ends of the capillary tube. Both samples were then analyzed. Micro-samples were then collected and given the same treatments. Finally the original syringe was re-analyzed to see there the action of collecting the capillary samples changed the partial pressures in the syringe from the baseline. The samples and baselines were then compared. We found that full capillary twirled samples had a lower $PcCO_2$ by 9.1% (standard deviation 4.1%) and that a rocked full sample had a lower $PcCO_2$ by 13.5% (standard deviation 8.2 %) from baseline. Twirled micro samples had a lower $PcCO_2$ by 13.6 % (standard deviation 13%) and rocked micro samples had a lower $PcCO_2$ by 45.4% with a standard deviation of 4%. When the source syringe was reanalyzed, PCO_2 had fallen by an average of 1%. PcO_2, which in the age of widespread use of pulse oximetry is less relevant, rose above or fell below baseline depending whether the original sample PO_2 was supra or sub atmospheric. In the case of sub atmospheric PO_2, the PcO_2 rose by 7.7% when full capillary tubes were twirled and 3.4% when rocked. Micro-samples with sub-atmospheric PcO_2 rose by 7.6% when twirled and 28% when rocked. Supra atmospheric O_2 full capillary samples (PO_2 160-220 torr) dropped by an average of 4.6% when twirled and by 6.4% when rocked. Micro-sample PcO_2 dropped by an average 5.7% when twirled and 5.7% when rocked. We recommend minimal agitation of capillary blood samples and only with twirling when necessary.

OF-01-077

ECMO As A Bridge To Interventional Catheterization: A Case Report

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Introduction: ECMO is valuable in the treatment of infants with severe reversible respiratory disease or severe reversible, low cardiac output refractory to medical management. This case study reports successful use of ECMO as a bridge to interventional catheterization in a patient with multiple left-sided heart obstructive lesions and severe left ventricular dysfunction.
Case Summary: A.S. is a three month old infant who presented to a local emergency department in cardiogenic shock with subsequent cardiorespiratory arrest. Resuscitation efforts included intubation, ventilation, dobutamine, dopamine, and ultimately high dose epinephrine. Diagnostic echocardiogram revealed severe coarctation of the aorta, severe aortic stenosis, markedly depressed left ventricular function (5% ejection fraction) and left atrial and left ventricular dilation. The patient was transported to Children's Hospital Medical Center and rapidly placed on ECMO due to refractory low cardiac output despite high dose epinephrine therapy. After a 40-hour stabilization period, the patient was transported to the cardiac catheterization laboratory on ECMO for balloon dilation of both the aortic valve and coarctation. The patient was decannulated from ECMO the next day, extubated two days post-dilation, and transferred back to the referring hospital four days post-dilation. Echocardiogram on discharge revealed markedly improved left ventricular function (ejection fraction 65%) and moderate aortic stenosis (peak gradient 34 mm Hg, mean gradient 18 mm Hg).
Significance: Interventional catheterization on ECMO is often avoided due to inherent risks and associated complexities. This case illustrates a dramatic recovery using the combination of ECMO and catheter intervention in a situation where surgical intervention would have been difficult. Consequently, use of ECMO as a bridge for interventional catheterization may be a treatment option in critically ill patients with refractory low cardiac output due to a correctable cardiac lesion.

OF-01-079

LABORATORY EVALUATION OF THE NEOPUFF INFANT RESUSCITATOR

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Introduction: The Neopuff Infant Resuscitator (Fisher & Paykel Inc.) is a manually triggered, manually cycled, pressure limited, pressure controller. Potential device uses include mechanical ventilation of infants during resuscitation, manual ventilation during transport; or a continuous flow nasal CPAP generator. This bench study was designed to evaluate peak inspiratory pressures (PIP), PEEP and inspiratory time (Ti) specifications at specific flowrates. **Methods:** To evaluate specifications for PIP and PEEP, we connected the single-limb breathing circuit to an Adult/Pediatric Lung Model (Ingmar Medical Inc.). Beginning at 5 lpm, and increasing flow in 1lpm increments (up to 15 lpm), minimum PIP and PEEP were determined by rotating the expiratory valve flow resistor fully counterclockwise (open position), while maximum PIP and PEEP were determined by dialing the flow resistor clockwise (closed position). We recorded pressure measurements from the lung model's manometer at each flow rate. Inspiratory time (seconds) was evaluated by selecting a desired PIP (25 cm H_20) and PEEP (5 cm H_20) and manually cycling the resuscitator into inspiration by occluding the open orifice on the expiratory flow resistor and manually cycling into exhalation as soon as the desired PIP was reached. An electronic hand-held pulmonary mechanics monitor (Breath Tracker 1705, CORE-M Precision Instruments Inc.), was placed in line and used to record T_I. The therapist performing the manual occlusions was blinded to the Ti readings during this portion of the study. Inspiratory time data was recorded for each flowrate (5-15 l/min). **Results:** Maximum peak pressures ranged from 25-40 40 cmH_20 (where the inspiratory pressure pop off was set). Minimum peak pressures ranged 6-23 cm H_20. Maximum PEEP ranged from 5-18 cmH_20. Minimum PEEP ranged 1-3 cm H_20.Maximum and minimum PIP and PEEP at each inspired gas flowrate, as well as, T_I are listed in the following table:

Flow L/min	PIP max.	PIP min.	PEEP max.	PEEP min.	Ti Sec
5	25	6	5	1	.8-1.0
6	30	6	6	1	.4-.6
7	36	9	7	1	.5-.6
8	37	12	9	2	.4-.6
9	38	15	12	2	.3-.4
10	40	16	13	2	.3-.4
11	40	22	16	2	.3-.4
12	40	22	18	3	.3-.4
13	40	22	18	3	.3-.4
14	40	22	18	3	.3-.4
15	40	22	18	3	.3-.5

Conclusion. Flowrates of 6-8 l/min provided the optimal range for PIP, PEEP, and Ti normally required for ventilating neonates. Little gas consumption is required to accomplish these goals. The only disadvantages seen in using this device from a benchtest standpoint is determination of T_I. Unless the clinician focuses on terminating the breath as soon as the desired peak pressure (PIP) is achieved, there is potential for prolonged inspiratory time or hyperventilation

OF-01-090

LOW END-TIDAL CO_2 ($EtCO_2$) IN THE VENTILATOR-DEPENDENT CHILD

Authors: Craig Davenport, RCP; Daved van Stralen, MD; Racquel Calderon, RCP, RTT; Larry Meissner, BA; Ravindra Rao, MD. Totally Kids Specialty Healthcare, Loma Linda, CA, and Loma Linda University Children's Hospital, Loma Linda, CA

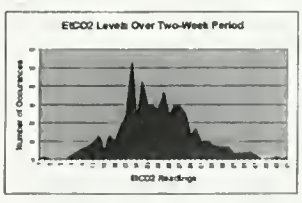
Purpose: In long-term care, patient-ventilator synchrony and comfort have a greater role in ventilator adjustment than blood gas analysis and sedative drugs. We evaluated the effect this has on $EtCO_2$ measurements.

Method: A descriptive study of 25 mechanically ventilated patients using retrospective chart review at a 50-bed freestanding pediatric subacute facility. $EtCO_2$ values are recorded once each on day and night shifts. Data came from 14 consecutive days without acute illness. Serum CO_2 levels came from routine serum electrolyte analysis. Ventilators were adjusted for ventilator-patient synchrony in a calm, awake patient. No sedative drugs were used. The ability to monitor blood gas, minute volume, or dead space was not available.

Results: About 50% of the time respiratory rate exceeded the ventilator set rate. $EtCO_2$ ranges occurred from 2-47 mmHg. They cluster around 17-28 mmHg (Chart 1.)

Serum CO_2 averages 18 mEq/L with a range of 11-25 mEq/L (Chart 2). Normal for our laboratory is 22-28 mEq/L. Ventilator circuits were changed 0-1 times during the study period. There was a single ventilator adjustment when one child had a rate change.

Chart 1



Conclusion: Adjusting the ventilator without blood gas analysis and for ventilator-patient synchrony in a calm, awake patient is possible and may produce low $EtCO_2$ with low serum CO_2.

Clinical Implications: $EtCO_2$ is generally accepted as an indicator of arterial CO_2 levels. In this study patients may have elevated $EtCO_2$, which is most likely from hypoventilation, and low $EtCO_2$, which is most likely from physiologic dead space ventilation. The cluster of low values of $EtCO_2$ and serum CO_2 levels indicates the patients develop respiratory alkalosis when ventilator settings are adjusted for comfort.

OF-01-091

NITRIC OXIDE WEANING FOR NEONATES: Raymond Malloy BS RRT, Brian Glynn BS RRT, Jay Greenspan MD. Departments of Pulmonary Care and Neonatology, Thomas Jefferson University Hospital, Philadelphia, PA

BACKGROUND: At Thomas Jefferson University Hospital, the Neonatal Intensive Care Unit's protocol for Nitric Oxide (NO) therapy is a newborn with Respiratory Distress Syndrome (RDS) who is > 34 weeks gestation with Persistent Pulmonary Hypertension of the Newborn (PPHN) and an Oxygen Index (OI) > 15. Infants who meet this criterion are treated with NO therapy and the method in which the infant is weaned from this therapy is central to subsequent need for extracorporeal membrane oxygenation (ECMO). HYPOTHESIS: We hypothesize that weaning patients FI02 first and then weaning the NO at small increments (5 parts per million) is appropriate for neonates with PPHN. METHODS: Twenty four patients were studied using the HFOV 3100A to optimize ventilation and oxygenation. NO therapy was started at 20 parts per million (ppm) and FI02 was reduced by 2-4% Q30 minutes-Q1 hour as long as the Pa02 was > 80 torr with Q2-3 hour arterial blood gases and a Sp02 > 94%. Once the FI02 is reduced to 60%, the NO is decreased to 15 ppm and then 10 ppm if the above criterion were met. The FI02 was then weaned by 2-4% Q1 hour as long as the Pa02 was > 80 torr with a Sp02 of > 94%. Once the FI02 was reduced to 40%, the NO was weaned to 5 ppm and then 2 ppm if the above criterion were met. At 2ppm with a Pa02 > 80 torr and a Sp02> 94%, the decision was made to discontinue NO therapy. The patients were placed on 1 ppm for 30 minutes prior to discontinuation of therapy.

RESULTS: The average time on NO was 52 hours with 75% of the patients studied not requiring ECMO and 25% of the patients studied requiring ECMO. The following separates patients studied by their diagnosis:

1. 14 Meconium Aspiration Syndrome (MAS) patients had an average time on NO of 38.6 hours with 93% of the patients studied not requiring ECMO and 7% of the patients studied requiring ECMO.
2. 6 RDS patients had an average time on NO of 68 hours with 67% of the patients studied not requiring ECMO and 23% of the patients studied requiring ECMO.
3. 4 CDH patients had a average time on NO of 36 hours with 25% of the patients not requiring ECMO and 75% of the patients studied requiring ECMO.

CONCLUSIONS: The average time on NO was 52 hours with 75% of the patients not requiring ECMO. We conclude that decreasing FI02 first and then decreasing NO in small increments yields positive results for weaning term neonates with PPHN receiving NO. Further studies are being investigated to wean NO within 4 hours from 20 ppm to 5 ppm in increments of 5 ppm and then wean the FI02 to 40% before turning the NO down to 2 ppm.

OF-01-121

MANAGEMENT OF A DIAPHRAGMATIC HERNIA IN A NEONATE USING A CONTINUOUS INTRAVACULAR BLOOD GAS SENSOR: A CASE REPORT

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BACKGROUND: Congenital Diaphragmatic Hernia (CDH) occurs in one of every 2000-5000 births and has a high morbidity and mortality. The survival of the newborn with CDH is dependent on the degree of lung maturity and the presence and reversibility of pulmonary hypertension. Hypoxia, hypercapnia, acidosis and hypothermia, precipitate pulmonary hypertension. Preventing these triggers during the immediate newborn period is crucial if an infant with a CDH is to survive.

CASE SUMMARY: The patient was a 40 week gestation male, 3.4 Kg, admitted to our NICU from an outlying hospital with respiratory distress and suspicion of diaphragmatic hernia per x-ray. Labor was complicated with decels late and meconium fluid. Infant was born vaginally. Apgar scores were 5 & 9 at 1 and 5 minutes. Spontaneous respiration occurred within 15-30sec; breath sounds reduced on left with scattered crackles. O2 was administered via mask. The infant soon displayed tachypnea and grunting with retractions. Saturations were 94% on FiO2 .27. No heart murmur was detected. Mediastinum and trachea were shifted to the right. Abdomen was scaphoid. No hepatosplenomegaly. Genitalia, lung, head & ENT, and reflexes all normal. Pt was transferred and admitted to NICU. Continuous blood gas monitoring using Neotrend (Agilent Tech.) revealed that the patient could maintain ABG homeostasis without intubation. Day 2, the patient was weaned off oxygen to room air. Day 3 patient went to surgery. Post op vent settings: Drager Babylog, PSG+VG Rate 30, 24/3 Vt 12,FiO2 .21. Total mechanical ventilation <96 hours. Surgical findings: Left congenital diaphragmatic hernia with intact hernia sac.

	Date	Time	pH	PCO2	PO2
Initial Value	10/26	1100	7.39	37	62
	10/26	1900	7.42	35	62
	10/27	0800	7.42	36	58
Pre-surgery	10/27	1400	7.45	36	62
Post Surgery	10/28*	0001	7.49	24	70
	10/29*	0600	7.43	30	82
	10/30*	0830	7.36	35	74

* intubated, mechanical ventilation

DISCUSSION: This defect was an atypical diaphragmatic hernia. With the use of continuous blood gas monitoring, mechanical ventilation was delayed until the defect could be surgically resolved.

OF-01-128

EXPANDED ROLE OF RCP's IN PERI-ANESTHESIA CARE OF PATIENTS IN THE RAPID TREATMENT UNIT. ; Michelle Porter, BA, RRT, Matt Peters, BSN; John Salyer, MBA, RRT, FAARC; Quality Care Assessment Team (QCAT). Respiratory Care Service, Outcomes Research Service, Rapid Treatment Unit. Primary Children's Medical Center Salt Lake City, UT

Introduction: Cross training of RCP's into non-traditional roles is increasing across the country. At our facility, several factors led to the development of the multidisciplinary team utilized to provide peri-anesthesia care (PAC) in our Rapid Treatment Unit (RTU). These factors included: 1) PAC was being done in many locations throughout the hospital by licensed independent practitioners, 2) there was variation in how this care was administered including non-standardized dosing and inconsistent monitoring, 3) many of these procedures were done in operating rooms which were under heavy scheduling pressure, 4) what was called "conscious sedation", was deep or level 1 anesthesia, 5) the RTU had space available for these procedures due to seasonal and daily patterns of utilization, and 6) the Quality Management Department identified this process as problematic and in need of redesign.

Program Structure: A multidisciplinary team was formed consisting of an anesthesiologist, RN and RCP to provide peri-anesthesia care in a non-operating room setting. Using the available space and resources in the RTU, patients from Hematology and Oncology who were anxious about procedures received anesthesia for lumbar punctures and bone marrow aspirates. As the service became established, other departments utilized the RTU PAC service. Patients needing electro-muscular graphing and botulism toxin injections, minor plastic surgery, and steroid joint injections used the service. The patients were selected using criteria such as past medical history, previous reaction to anesthesia, or current illness. More complex or unstable patients were sent to the operating room for procedures. **Training and Team Composition:** It was determined that RCP's have the assessment skills and training to evaluate and monitor these patients and thus would be an interchangeable part of this care team (with RN's). Training and experience requirements included: 1) Member of the QCAT, 2) RRT with 6 months of PICU experience,3) Pediatric Advanced Life Support (PALS) certification and 4) Neonatal Resuscitation Program (NRP). In addition the RCP's are required to complete general pharmacology, fluid balance and electrolyte modules which were created by a team member for RCP's from a nursing curriculum. The RCP must spend 3 shifts with the team for mentoring. Some nurse managers expressed concern that RCP's were not properly licensed for such care. The Utah Respiratory Care Practice licensure act does not specifically limit what an RCP can do, except the administration of blood products, as long as the RCP is acting under the direction of a physician.

Conclusion: By forming this team, we have effectively cross-trained an RT/RN team as interchangeable members in this setting as well as improved resource utilization. We speculate there are several benefits such as 1) parents have better access to the patients during the peri-anesthesia period, 2) time in the hospital and cost are both reduced, 3) scheduling difficulties in operating room is relieved, 4) standard of care is more consistent throughout the hospital for PAC, and 5) RTU resources are effectively used. We are currently building data systems to evaluate our efficiency, in comparison to the OR. Recently acquired follow-up surveys show parents and patients are very satisfied with this service. RCPs are qualified to manage the airway, assess vital signs and perform nursing duties when trained. Although we have encountered challenges such as a need for more education and territorial issues with recovery room nurses, it has been an eye opening, door opening experience. This expanded role has been viewed as a positive step in process improvement in dealing with the variations in sedation/anesthesia practice as well as increasing the value of the RCPs to the hospital.

OF-01-194

USE OF A BRONCHIOLITIS SYMPTOM SCORING SYSTEM IN INFANTS Julie Ballard RRT BS, QCAT Members, and John Salyer RRT MBA FAARC. Respiratory Care Services, Primary Children's Medical Center and School of Medicine, University of Utah, Salt Lake City, UT. **Introduction:** Our multidisciplinary Quality Care Assessment Team (QCAT) evaluates and recommends appropriate respiratory care for non-ICU bronchiolitis pts (Respir Care 1998;43:867). They utilize a respiratory symptom based bronchiolitis scoring system that helps to determine effectiveness of care and severity of illness. This system evaluates and assigns scores to each pt based on the respiratory rate, breath sounds and retractions. Scores are classified 0-1 normal, 2-3 mild distress, 4-6 moderate distress, and 7-9 severe distress. Additionally, all discharges are classified to a severity category (1 through 4, lowest to highest) based on diagnostic and procedural coding using All Patient Refined – Diagnosis Related Group, Severity of Illness (SOI). We sought to test whether there was an association between these two severity scoring systems and other indicators of severity, such as O_2 requirement, LOS and resource consumption. **Methods:** Inclusion criteria were 1) age ≤ 24 months 2) non-ICU 3) dx of bronchiolitis and 4) documentation of at least 1 bronchiolitis score. We excluded any pts receiving O_2 by mask or blow-by. The study period was Oct-2000 through Apr-2001. Most of these pts were admitted through the ED, but only the initial score obtained after floor admission was used. Length of Stay (LOS) in hours, costs, charges, and SOI were obtained from our hospital case-mix database. Bronchiolitis scores and O_2 requirements were obtained from retrospective chart review. Liter flow was adjusted as needed to keep pulse oximetry levels ≥ 88%. Categorical data were tested with Chi square and means testing was ANOVA with significance set at $P < 0.05$. **Results:** 512 pts met the criteria for the study. Seven pts were excluded because of incomplete data and 12 because they received O_2 by mask or blow-by, leaving 493 pts in our study. The initial score was obtained on average 5.4 hrs after floor admission.

Initial score	n	LOS (hours)	Costs ($)	Charges ($)	O_2 (L/m)	SOI-1 Count	SOI-2 Count	SOI-3 Count	SOI-4 Count
0-1	24	54	2555	3685	0.53	11	12	1	0
2-3	232	77	3769	5372	0.58	83	113	29	7
4-6	216	79	3365	4864	0.77	70	111	31	4
7-10	21	131	7895	11,449	1.18	7	6	6	2

LOS, Costs, Charges and O_2 are mean values and all yield ANOVA $P < 0.05$

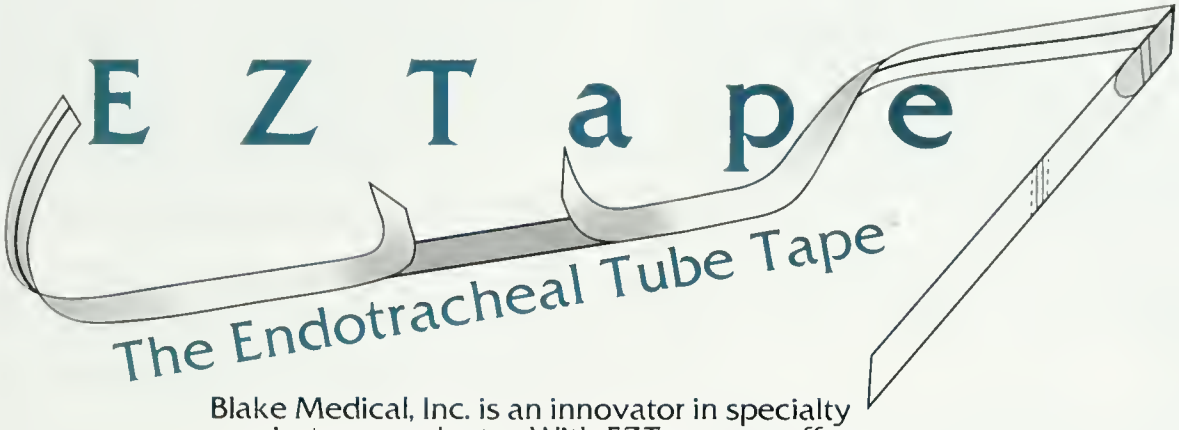
SOI vs bronchiolitis score Chi Square P-Value = 0.13

Conclusion: There appears to be an association between the bronchiolitis score and resource consumption. The slight drop in costs and charges between the mild and moderate levels are probably due to scoring limitations, which include looking only at respiratory symptoms. The most compelling evidence of the effectiveness of the bronchiolitis score is the trend upward in O_2 requirements with increasing scores, since the score, as well as O_2 requirements really focuses on respiratory symptoms. The inconsistent association with the SOI scores is disappointing and probably explained by the fact that the SOI looks at diagnoses, co-morbidities, procedures, and age, and includes no symptom measures. We have been using the bronchiolitis score since 1997 and find it very helpful in clinical decision making.

OF-01-238

EZ Tape

The Endotracheal Tube Tape



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ADULT HIGH FREQUENCY OSCILLATOR PATIENT DEMOGRAPHICS

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Background: Previous analysis of HFOV on patients over 35 kg has centered on strategies (Pdelta, ETT size, MAP etc.) for ventilating this patient population. This examination scrutinized patient demographics to see if any predictable trends developed to aid in selecting the best candidates for use of the Sensormedics 3100a HFOV. Method: A concurrent review of patient data upon institution of ventilation examined the following, patient age, gender, weight, diagnosis, interval between ventilation and changing to HFOV, duration of HFOV , interval to stabilization by HFOV, respective oxygen indexes and P/F ratios. Of the nearly 40 adult patients ventilated in this facility using the 3100a since 1996, 10 representative patients were selected. Results: The patients who survived to discharge were 11 years younger, weighed 6 kg less, spent 7 fewer hours on conventional ventilation, required less HFOV time, had their oxygenation stabilized 9 hours sooner, and exhibited higher OI/PFs than the patients that died. Conclusions: Outcomes in this group of ARDS patients (>35kg) were markedly improved by beginning HFOV earlier. What is intuitive for determining which patients would do best was in fact bore out. See table. The youngest, smallest patient set faired the best, as did the patients who had HFOV instituted earliest in their clinical course. These exhibited an approximate halfing of their OIs and a doubling of their PFs following HFOV initiation. Too much significance should not be attached to this small sample size. Further examination of data from other tertiary care centers would aid in trending.

Patient-Survivors (A)	#1	#2	#3	#4	#5	Average	A-B=
Age (years)	36	25	49	22	46	35.6	11.4 yrs
Sex	F	F	F	F	F		
Wt (kg)	67	73	63	61	74	67.6	6.2 kg
Diagnosis	ARDS	ARDS	ARDS	ARDS	ARDS		
Time on CV (hours)	112	11	3	10	134	54	7.4 hrs
Time on HFO (hours)	118	24	30	59	108	67.8	22.9 hrs
Hrs until ABGs stable	2.5	1	2.6	5.5	7.5	3.82	9.7 hrs
OI Prior HFO	77.5	22.6	8	24.6	60	38.54	-5.32
OI on HFO	10.1	25.3	6.8	17.5	50	21.94	11.4
OI when ABGs stable	32.8	7.7	15.6	11.4	13.2	16.14	5.44
PF on CV	65	86	139	65	55	82	-2.4
PF on HFO	377	129	67	160	76	161.8	-21.8
PF when ABGs stable	58	362	193	211	280	220.8	-30.8

CV, Conventional Ventilation, HFO, High Frequency Oscillator, OI, Oxygen Index; PF, Pa02/Fi02

Patient-Deceased (B)	#6	#7	#8	#9	#10	Average
Age (years)	35	67	36	33	64	42.75
Sex	M	M	F	F	M	
Wt (kg)	73	105	67	62	62	76.75
Diagnosis	ARDS	IVH/DIC	ARDS	ARDS	ARDS	
Time on CV (hours)	62	30	10	41	164	35.75
Time on HFO (hours)	104	71	2.4	85	191	65.6
Hrs until ABGs stable	4	2.5	1	59	1.1	16.625
OI Prior HFO	34.3	19	50	17.8	45	33.22
OI on HFO	56.1	57.6	13.1	19.8	20.1	36.65
OI when ABGs stable	36.5	28.8	13	12.5	17.1	22.7
PF on CV	70	58	75	135	60	84.5
PF on HFO	57	52	251	166	174	131.5
PF when ABGs stable	96	125	239	280	210	185

IVH/DIC, Interventricular Hemorrhage/Disseminated Intervascular Coagulopathy

OF-01-084

BALANCING CARBON DIOXIDE LEVELS WITHIN THE EXTRACORPOREAL MEMBRANE OXYGENATOR PUMP PRIOR TO INITIATING PATIENT USE.

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INTRODUCTION: The continued use of *Extracorporeal Membrane Oxygenation* (ECMO) has led to a search for ways to shorten the time required to completely prime an ECMO pump for patient use. Activation of the ECMO team is usually emergent in nature, thus making pump availability an important factor in patient outcome. Many aspects of the priming process have been evaluated for reduction of time required. The balancing of *Carbon Dioxide* (CO2) in the fully primed pump is evaluated in this technique review. By identifying the relationship between ECMO Blood Flow rate (pump flow), gas flow rates (sweep flow), and time of exposure between the two, the amount of time required to fully balance the CO2 levels within the pump may be arrived at with relative certainty in a set time frame. The time prior to initiating ECMO is spent balancing blood gas values, sodium bicarbonate levels and electrolytes. By creating repeatable trials of CO2 manipulation, a formula is derived that suggests the gas flow and time required at fixed pump flow rates to achieve the desired CO2 level in the blood primed pump.

METHODS: A standard *Medtronic Cardiovascular* 1/4" tubing circuit with a .8 meter squared membrane oxygenator set up according to departmental standards was used. The circuit was primed with human blood and hemoglobin levels were maintained above 6.0gm% throughout trials. The ECMO blood flow rate was maintained at 200 cc/min (Due to the absence of a patient, the flow rate cannot be expressed in cc/kg/min.), and the sweep gas blender setting was held constant at 21% oxygen. CO2 levels were manipulated by adjusting the Air/O2 flow rates or the CO2 flow rates depending on desired outcome. For increasing CO2 levels a constant pump flow of 200 cc/min with a CO2 flow rate of .2 lpm were used for various time increments. For decreasing CO2 levels a constant pump flow of 200 cc/min with an Air/O2 flow rate of 2 lpm for various time increments.

RESULTS: The linear nature of a graph depicting increasing CO2 by time increments suggested that a relative ratio exist that could be used to estimate CO2 manipulation. A graph depicting decreasing CO2 by time increments remained relatively linear up to three minutes then became more exponential. This suggests that a blood gas or other evaluation method should be sampled at the three minute mark and adjustments made accordingly.

CONCLUSIONS: Averaging the values of the various time increment exposures led to the formulation of the following calculations.

Increasing CO2 by Time Increments
△CO2 / TIME in Sec. = Average Ratio For All Values
△CO2 / Sec. = .26

Decreasing CO2 by Time Increments
△CO2 / TIME in Sec. = Average Ratio For Values Up To Three Minutes
△CO2 / Sec. = .34

OF-01-085

FORTY PERCENT HELIOX PROVES BENEFICIAL IN A MECHANICALLY VENTILATED ADULT.

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Introduction: Helium-Oxygen (heliox) is a low-density gas mixture. Inhalation of heliox reduces airway resistance and the pressure required to overcome resistance. This enables ventilation at lower peak pressures. Heliox can decrease the patient's work of breathing and may improve ventilation to perfusion matching. Carbon dioxide diffuses four to five times faster through heliox than nitrox; therefore, a greater amount of CO_2 will be eliminated per unit of time. The benefits of heliox have been documented for the treatment of respiratory failure due to status asthmaticus. Density of helium-oxygen mixtures is lowest at higher helium concentrations. Theoretically, for the patient to receive the greatest benefit from heliox therapy, the highest possible concentration of heliox should be utilized. At times, heliox is not initiated, due to the need for a higher fraction of inspired oxygen (FiO_2), in the belief that a lower concentration of heliox will not be effective. This case study documents the outcome of 40/60 heliox concentration in an intubated, mechanically ventilated, adult asthmatic. **Case Summary:** A 71 year-old female presented to the Emergency Department with acute status asthmaticus. She was started on methylprednisolone intravenously and continuous albuterol nebulizer treatments. An arterial blood gas sample (ABG) was drawn with the patient on an aerosol mask while receiving bronchodilator treatments: pH 7.23, PCO_2 66, PO_2 311, and HCO_3 27. The patient was electively intubated and ventilated with a Servo 300A ventilator. The ventilator settings were Pressure Regulated Volume Control (PRVC) mode, Tidal Volume (VT) 500 ml, peak pressure of 32 cmH_2O, PEEP of 0, respiratory rate of 14, I:E ratio of 1:3, and 60% FiO_2. On those settings, arterial pH was 7.24 mmHg and CO_2 was 57mmHg. Immediately after 40/60 heliox was initiated, peak airway pressure dropped from 32 cmH_2O to 20 cmH_2O. An ABG drawn 85 minutes after initiation of heliox showed improvement of arterial pH to 7.40 mmHg and CO_2 decreased to 37 mmHg. The 500cc tidal volume and all other initial ventilator settings were maintained. **Discussion:** This comparatively low concentration of heliox (40/60) lowered the peak airway pressures in this patient and improved ventilation. The FiO_2 was weaned, heliox percentage increased, and then the heliox was discontinued two hours prior to successful extubation on hospital day three. When to initiate heliox and the concentration at which to begin, are key components literature has not yet addressed. Solutions may include looking at individual disease processes and specific delivery devices. Previously, we described an adult asthmatic who showed an improvement in ventilation with 60/40 heliox. This case study documents that a concentration as low as 40/60 heliox was beneficial in a conventionally ventilated adult asthmatic. More research is required to determine which patients will respond to heliox and what minimal percentage of heliox is required to achieve any beneficial effect.

OF-01-089

LONG-TERM VENTILATION: PRESSURE OR VOLUME?

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Purpose: Volume Control (VC) may be used for long-term ventilation. We report four patients who developed respiratory insufficiency while receiving VC. They responded to Pressure Control (PC) ventilation by calming. **Methods:** Retrospective case studies of four ventilator dependent patients in a 50-bed, freestanding, pediatric subacute facility. **Results:** Patient 1: 18 year-old male with muscular dystrophy. Initial settings: Synchronized Intermittent Mandatory Ventilation (SIMV) with Pressure Support (PS) of 15cm H_2O, inspired tidal volume (V_T) 400cc (15cc/kg) and expired 373cc. Problem: Agitation and poor chest expansion. New settings: PC ventilation, expired V_T of 403cc. Discomfort resolved with calming. Patient 2: 17 year-old male with traumatic brain injury. Initial settings: SIMV 18, inspired V_T 1100cc (20cc/kg), expired V_T 40-45 cc. Problem: pneumonia, peak pressure 50cm H_2O, poor chest expansion. Final settings: PC 40cm H_2O, good chest expansion. Patient 3: 14 year-old male with profound mental retardation and cerebral palsy. Initial settings: AC 16, V_T325cc (11cc/kg). Problem: Low volume alarms, absent breath sounds (stoma air leak). Final settings: PC 30cm H_2O, expired V_T 250-300cc, positive breath sounds. Patient 4: Seven month old female with Ellis-van Creveld Dwarfism. Initial settings: AC 14, PS 15cm H_2O, VT 40cc (15cc/kg). Problem: nasal flaring, retractions, agitation. Final settings: AC 25, PC 18cm H_2O. Patient became playful. **Conclusions:** In these four patients, PC ventilation calmed the patient and increased chest expansion while decreasing other signs of respiratory distress. **Clinical Implications:** Ventilator-dependent patients with agitation or respiratory distress may benefit from PC ventilation.

OF-01-093

INITIATION OF POSITIVE END EXPIRATORY PRESSURE (PEEP)

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Purpose: Will PEEP improve oxygenation and ventilation after failure of other therapies in a long-term care facility?

Methods: A descriptive study of two years retrospective data from chart review at a 50-bed freestanding pediatric subacute facility. PEEP was administered after inability to maintain oxygen saturation over 90% on F_iO_2 0.50 or improve ventilation after failure of bronchodilators (albuterol and/or terbutaline with atrovent). No sedative drugs were used. PEEP was titrated to a calm, awake patient with normalized inspiratory/expiratory ratio (I:E), pulse oximetry greater than 90%, and without acute increase in $EtCO_2$.

Results:

Oxygenation: *Before* - 23 patients receiving mechanical ventilation, FIO_2 0.50 acutely; ventilator-patient asynchrony by clinical exam

After - PEEP 2-8 cm H_2O (average 4 cm H_2O), FIO_2 less than 0.50 synchrony between patient and ventilator

Ventilation: *Before* - Dynamic hyperinflation from Status asthmaticus; ventilator-patient asynchrony, prolonged expiratory phase (see Table 1)

After - PEEP 5-8 cm H_2O (average 7 cm H_2O); ventilator – patient synchrony; I:E ratio 1:2.

No patient was transferred to the emergency department. No chemical or physical restraints were used

Table 1. **$EtCO_2$ Before and After PEEP**

Patient	1	2	3	4	5	6	7	8
PEEP	7	8	8	6	6	5	7	7
CO_2 Before	Not obtained	Not obtained	62	60	48	46	41	35
CO_2 After	Not obtained	Not obtained	50	54	36	18	35	25

Conclusion: PEEP can improved gas exchange and ventilator – patient synchrony while calming the patient in the long-term care setting.

Clinical Implications: PEEP can be used out of the intensive care unit following clinical examination for both oxygenation and ventilation problems.

OF-01-095

DOES ASSIST CONTROL (AC) VENTILATION EQUAL SYNCHRONIZED INTERMITTENT MANDATORY VENTILATION (SIMV) WITH PRESSURE SUPPORT (PS)

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Purpose: Children receiving long-term invasive mechanical ventilation (MV) may use the SIMV mode. Some receive PS because their spontaneous respiratory efforts may not provide effective ventilation, or to aid weaning. Can more basic AC mode of MV replace the more complex method of ventilation, SIMV+PS? **Methods:** A retrospective chart review in a 50-bed, freestanding, pediatric subacute facility. Eleven cases were identified with SIMV+PS who received a trial of AC. **Results:** Patients ages: 2-18 years old; ten male, one female. Ten out of eleven patients were successfully converted to AC from SIMV+PS, as demonstrated by remaining on AC, with no "911 calls," no sedation, and no change in the 5-Point Respiratory Exam. The 5-Point Respiratory Exam is a clinical assessment which evaluates alertness, respiratory rate and rhythm, oximetry, work of breathing, and air entry. One patient was not able to tolerate the conversion.

Ventilator Settings	*Number of Potients*
SIMV+PS	11
Conversion to AC	
Successful	10
Unsuccessful	1
Length of time on SIMV+PS	
> one year	2
< one year	9

Conclusions: In ten out of eleven cases, the children were successfully converted to AC. **Clinical Implications:** Patients on SIMV receiving PS to supplement tidal volume may benefit from a change to AC alone, a less complex ventilator setting, allowing them to be discharged on a home ventilator.

OF-01-099

THE NATURE OF UNSTABLE VENTILATORY SUPPORT DURING PSV IN A LUNG MODEL OF OBSTRUCTIVE DISEASE.

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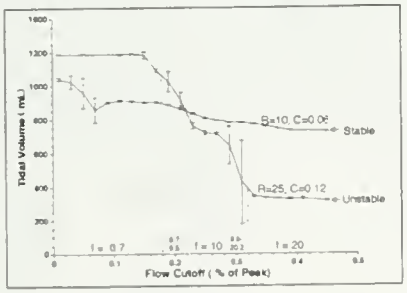
Background: Previous investigations have suggested that pressure support ventilation (PSV) develops dynamic instability in a model of airway obstruction. To explore the nature of this instability, we investigated the variability of tidal volume (V_T) delivery during PSV under combinations of respiratory resistance and compliance under a range of inspiratory flow cutoff levels. **Methods:** A mechanical test lung (Hans Rudolph, Kansas City, MO) was used to simulate spontaneously breathing patients with combinations of resistance (R=25, 20, 15, 10 $cmH_2O/L/s$) and compliance (C=0.12, 0.10, 0.08, 0.06 L/cmH_2O), and respiratory efforts at 20/min. The test lung was ventilated with bilevel pressure support at 22 cm H_2O, PEEP = 5 cm H2O (model 840, Mallinckrodt, Carlsbad, CA) at inspiratory flow cutoff levels of 45% to 1%. **Results:** The figure depicts examples of 2 conditions: stable and unstable support conditions. Mean V_T (± SD) from 20 consecutive breaths is plotted – dependent upon inspiratory flow cutoff settings. The stable support occurred with low resistance (R=10)/ moderate compliance (C=.06) and produced a constant frequency of 20/min. The high resistance (R=25)/ high compliance (C=.12) condition resulted in variable V_T and dropped breaths producing an unstable frequency (range of 6.7 to 20/min). **Conclusion:** Unstable ventilatory support during PSV, a variable V_T and a decrease in respiratory frequency, can occur at lower inspiratory flow cutoff levels in obstructive disease conditions. Therefore, optimizing the inspiratory flow cutoff setting may improve patient-ventilator synchrony.



OF-01-104

EFFECT OF RECRUITMENT MANEUVERS ON END-EXPIRATORY LUNG VOLUME IN A PRESERVED PORCINE LUNG MODEL.

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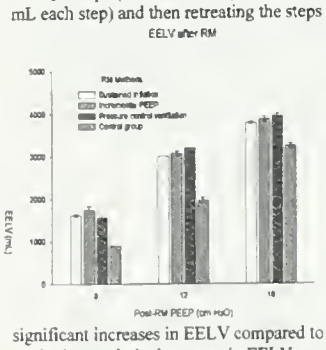
Background: Mechanical ventilatory strategies have been proposed to "open the lung and keep it open" – the strategies have been termed recruitment maneuvers (RM). However, questions remain about the effectiveness of each type of RM. This study was designed to investigate the effects of different RM techniques on end-expiratory lung volume (EELV) in a preserved porcine lung model (Nasco BioQuest®, Fort Atkinson, WS). **Methods:** Baseline mechanical ventilation was VT=300 mL, f=22/min, PEEP=8 cm H_2O, and I:E=1:2. For each of the currently proposed RM techniques, we examined the effects on EELV of the RM and three post RM PEEP levels: 8, 12, and 16 cm H_2O. The RM methods were: (1) sustained inflation: CPAP at 35 cm H_2O for 20 s, (2) incremental PEEP: increasing PEEP by 6 cm H_2O steps (30 sec each step) to 30 cmH_2O while decreasing tidal volume (30 mL each step) and then retreating the steps to a post RM PEEP level, (3) pressure control ventilation: Pset=45 cm H_2O with PEEP=20 cmH_2O for 2 min, (4) control group: no RM, with PEEP at 8, 12, and 16 cm H_2O. EELV was measured by applying ZEEP and routing the EELV into a spirometer (Collins, Braintree, MA). All EELV measurements were repeated three times and analyzed by ANOVA with Bonferroni's *post hoc* analysis. **Results:** In all four groups, EELV increased significantly as post RM PEEP was increased ($p < 0.001$). The three RM methods produced significant increases in EELV compared to control ($p < 0.001$). For the three RM methods tested, the increases in EELV were not consistently different between methods. **Conclusions:** EELV was significantly increased by the post RM PEEP setting and by each of the RM methods tested.



OF-01-105

INCIDENCE OF RESPIRATORY DISTRESS OR PATIENT-VENTILATOR DYSSYNCHRONY DURING LOW V_T VENTILATION IN PATIENTS WITH ACUTE LUNG INJURY (ALI)

RH Kallet, MS RRT, JA Alonso RRT, L Martin RRT, M Eisner MD, JM Luce MD.
NHLBI ARDS Clinical Trials Network at San Francisco General Hospital (SFGH)

Background: The incidence of respiratory distress and/or patient-ventilator dyssynchrony (distress/dyssynchrony) during low V_T ventilation is unknown. We gathered preliminary information by reviewing the medical records of all 43 patients enrolled into the ARDS Network low V_T study at SFGH and randomized to low V_T (6mL/kg) or traditional V_T (12 mL/kg) ventilation. Methods: Protocol-directed ventilator adjustments were made with the intention of minimizing inspiratory flow rate $\dot{V}_I$ and inspiratory-phase dyssynchrony. The ventilator flow sheets and nursing notes were reviewed retrospectively for all documented incidences of distress/dyssynchrony during the first 24 h of protocol management. Data was expressed as mean (± standard deviation) and comparisons were made using Mann-Whitney tests. The relative risk for distress/ dyssynchrony was assessed by two-sided Fisher's Exact test. Alpha was set at 0.05. Results: Distress/ dyssynchrony was documented in 67% (14/21) of the patients in the low V_T group, and in 36% (8/22) of the patients randomized to traditional V_T. The risk of developing distress/dyssynchrony during low V_T ventilation was 1.83, but failed to achieve statistical significance (p = 0.069).

Variable	Low V_T	Traditional V_T	p
V_T	6.8 ± 0.9 mL/kg	11.8 ± 1.1 mL/kg	< 0.0001
$\dot{V}_E$	16.0± 3.3 L/min	12.7 ± 2.9 L/min	0.0011
$\dot{V}_I$	86.1 ±20.1 L/min	65.1 ± 20.1 L/min	0.0017
Set f	29.2 ± 5.3	14.3 ± 4.8	<0.0001
Assist f > set f	1.2 ± 2.4	0.6 ± 0.9	0.46
P_{SENS}	-1.2 ± 0.5 cmH_2O	-1.4 ± 0.5 cmH_2O	0.10
pH	7.35 ± .07	7.39 ± .06	0.09
$PaCO_2$	36.1 ± 7.4 mm Hg	35.7 ± 6.6 mm Hg	0.80
PaO_2	79.9 ± 13.5 mm Hg	91.3 ± 22.9 mm Hg	0.09
BE	-5.0 ± 5.9 mEq/dL	-3.3 ± 4.9 mEq/dL	0.33

Conclusion: There was a trend toward increased distress/dyssynchrony during low V_T ventilation despite a high peak $\dot{V}_I$, low trigger sensitivity (P_{SENS}) and a set f close to total f. This implies that traditional ventilator adjustments to optimize patient comfort may not be sufficient during low V_T ventilation. However, the distress/dyssynchrony trend may be influenced by the fact that patients in the low V_T group also had a higher minute ventilation $\dot{V}_E$ demand and a trend towards a lower pH, which may suggest more severe illness.

NIH R01-HL51856

OF-01-112

CHARACTERISTICS OF ACUTE LUNG INJURY (ALI) PATIENTS EXHIBITING RESPIRATORY DISTRESS OR DYSSYNCHRONY DURING LOW V_T VENTILATION

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Background: The incidence of respiratory distress and/or patient-ventilator dyssynchrony during low V_T ventilation is unknown. We gathered preliminary information by reviewing the medical records of all 21 patients enrolled into the ARDS Network low V_T study at SFGH and randomized to low V_T (6mL/kg) ventilation. **Methods:** Protocol-directed ventilator adjustments were made with the intention of minimizing inspiratory flow rate $\dot{V}_I$ and inspiratory-phase dyssynchrony. The ventilator flow sheets and nursing notes were reviewed retrospectively for all documented incidences of distress/dyssynchrony during the first 24 h of protocol management. Data was expressed as mean (± standard deviation) and comparisons were made using Mann-Whitney tests. The relative risk for distress/ dyssynchrony was assessed by two-sided Fisher's Exact test. Alpha was set at 0.05. **Results:** Distress/ dyssynchrony was documented in 67% (14/21) of the patients in the low V_T group. Patients exhibiting signs of distress/dyssynchrony had a trend toward a lower pH, base excess (BE), and tended to require a higher V_T despite equivalent settings for peak $\dot{V}_I$, set f and trigger sensitivity (P_{SENS}). The relative risk of developing distress/dyssynchrony when the BE > -5 mEq/dL was 2.05, but failed to achieve statistical significance (p = 0.08).

Variable	Distress/Dyssynchrony	Apparent Synchrony	p
V_T	7.0 ± 0.99 mL/kg	6.5 ± 0.6 mL/kg	0.076
$\dot{V}_E$	16.4 ± 3.2 L/min	15.5 ± 3.6 L/min	0.55
$\dot{V}_I$	88.8 ± 19.6 mL/kg	81.7 ± 21.6 mL/kg	0.49
Set f	29.7 ± 5.3	28.3 ± 29.7	0.75
Total f	31.3 ± 5.7	28.8 ± 5.2	0.34
P_{SENS}	-1.0 ± 0.3 cmH_2O	-1.4 ± 0.6 cmH_2O	0.49
pH	7.34 ± .08	7.38 ± .06	0.27
$PaCO_2$	34.8 ± 8.4 mm Hg	38.4 ± 5.0 mm Hg	0.27
PaO_2	82.7 ± 14.9 mm Hg	75.3 ± 10.0 mm Hg	0.47
BE	-6.3 ± 6.5 mEq/dL	-2.7 ± 4.4 mEq/dL	0.18

Discussion/Conclusion: Setting a high peak $\dot{V}_I$, f and low P_{SENS} may not be sufficient to prevent distress/dyssynchrony during low V_T ventilation. Chronic metabolic acidosis increases ventilatory drive.[1] Therefore, our data suggests an intriguing research question: will correcting metabolic acidosis improve patient tolerance of low V_T ventilation? This may be clinically relevant when high levels of sedation or paralytic agents are required to treat distress/ dyssynchrony, or a desired target V_T cannot be achieved. (NIH R01-HL51856)

1. Berger AJ, et al. Regulation of respiration. N Engl J Med. 1977; 297(4):194-201.

OF-01-113

SEDATION AND NEUROMUSCULAR BLOCKING AGENT (NMBA) REQUIREMENTS DURING INITIATION OF LOW V_T VENTILATION IN PATIENTS WITH ACUTE LUNG INJURY (ALI)

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Background: The amount of sedation and use of NMBA required to treat respiratory distress and/or patient-ventilator dyssynchrony (distress/dyssynchrony) during low V_T ventilation is unknown. Methods: The medical records of all 43 patients enrolled into the ARDS Network low V_T study at SFGH and randomized to either low V_T (6mL/kg) or traditional V_T (12 mL/kg) ventilation were reviewed retrospectively to determine both sedation/NMBA use, and the incidence of distress/ dyssynchrony during the first 24 h of protocol management. Total sedation requirements and Ramsey sedation scores were calculated. All analgesics and sedatives were converted to fentanyl and lorazepam equivalents and expressed in mg/day.[1] Data was expressed as mean (± standard deviation) and comparisons were made using Mann-Whitney tests. NMBA use was assessed by two-sided Fisher's Exact test. Alpha was set at 0.05. Results: Distress/ dyssynchrony was documented in 67% (14/21) of the patients in the low V_T group, and in the 36% (8/22) of the patients randomized to traditional V_T. Yet the total amount of analgesics and sedatives administered were not different. A trend towards higher NMBA use was found in the 12 mL/kg V_T group (relative risk = 1.64; p = 0.24). NMBA's were administered prior to enrollment in all 6 patients in the 12 mL/kg V_T group, and after enrollment in both patients in the 6 mL/kg V_T group. When sedation/analgesic requirements were assessed in each V_T group based upon the presence of distress/ dyssynchrony, only the benzodiazepam dosages were different in the low V_T group.

	Low V_T	Traditional V_T	p
Fentanyl (mg/d)	2.7 ± 2.3	2.5 ± 2.4	0.55
Lorazepam mg/d	19.4 ± 10.6	17.5 ± 14.8	0.37 Propofol (g/d)
	2.94 ± 1.63	2.70 ± 3.05	0.86
Baseline Ramsey	3.5 ± 1.5	3.8 ± 1.6	0.42
Day 1 Ramsey	4.2 ± 1.6	3.6 ± 1.8	0.28
Low V_T Group	Dyssynchrony	Synchrony	p
Lorazepam mg/d	14.7 ± 10	28.2 ± 4.6	0.007

Conclusion: Distress/dyssynchrony was higher in the low V_T group despite equivalent administration of sedatives/analgesics. This may suggest that higher levels of analgesics/sedatives (particularly benzodiazepams) may be required to treat distress/dyssynchrony during low V_T ventilation. However, the trend towards higher NMBA use in the traditional V_T group may have masked the opportunity to detect distress/dyssynchrony.

1. Cammarrano WB, et al. Acute withdrawl syndrome realted to the administration of analgesic and sedative medications in adult intensive care unit patients. Crit Care Med. 1998; 26(4): 676-684 (NIH R01-HL51856)

OF-01-114

DOES HIGH LEVEL MINUTE VENTILATION $\dot{V}_E$ DEMAND LIMIT IMPLEMENTATION OF THE ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS) NETWORK LOW V_T VENTILATION PROTOCOL?

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Background: Because the ARDS Network low V_T protocol places an upper limit of 35 on the set respiratory rate, there also is an upper limit of pre-set $\dot{V}_E$ that can be achieved when the V_T is reduced to 6 mL kg. This may present a potential difficulty in implementing the protocol in patients with high $\dot{V}_E$ demand. We retrospectively assessed the potential for high $\dot{V}_E$ demand to limit the achievement of protocol goals by analyzing data from the ARDS Network low V_T study. **Methods:** All patients randomized to the low V_T ventilation protocol were assigned to 3 groups based upon the level of $\dot{V}_E$ demand prior to randomization: $\dot{V}_E$ < 15 L/min, 15-18 L/min, and > 18 L/min. The pH, $PaCO_2$, P_{PLAT}, V_T from the reference period on study day 1(approximately 6-24 h after randomization) were compared between groups.

Pair-wise multiple comparisons between the $\dot{V}_E$ groups were made using Tukey-Kramer tests. Between-group differences in variables (in terms of being within or outside protocol target range) was analyzed by Chi Square Tests. Alpha was set at 0.05. **Results**: No differences were found in V_T, P_{PLAT}, $PaCO_2$ and arterial pH when the $\dot{V}_E \leq$ 18 L/min. When $\dot{V}_E$ was > 18 L/min, pH was significantly lower than the other groups and V_T was significantly higher than the lowest $\dot{V}_E$ group. The incidence of P_{PLAT} exceeding the upper protocol limit (30 cm H_2O) was nearly doubled when $\dot{V}_E$ exceeded 18 L/min 23.8% vs. 14.1%), but was not statistically different. The incidence of V_T exceeding the upper protocol limit (> 6.5 mL/kg) was significantly higher as $\dot{V}_E$ exceeded 15 L/min (13.7% at < 15 L/m vs. 26 and 30.3% at 15-18 and > 18 L/m respectively).

$\dot{V}_E$ Group	Variable	Pre-enrollment	Day 1
< 15 L/m	V_T (mL)	10.1 ± 2.0	6.1 ± 0.8
	P_{PLAT} (cmH_2O)	29.0 ± 7.4	24.5 ± 6.5
	$PaCO_2$ (mmHg)	37.8 ± 7.6	40.2 ± 8.8
	pH	7.40 ± 0.07	7.39 ± 0.08
15-18 L/m	V_T (mL)	10.1 ± 1.9	6.3 ± 0.9
	P_{PLAT} (cmH_2O)	30.8 ± 8.1	25.6 ± 5.7
	$PaCO_2$ (mmHg)	36.1 ± 8.2	40.3 ± 11.1
	pH	7.39 ± 0.08	7.38 ± 0.07
> 18 L/m	V_T (mL)	10.4 ± 1.9	6.5 ± 1.3*
	P_{PLAT} (cmH_2O)	31.8 ± 8.3	26.3 ± 7.7
	$PaCO_2$ (mmHg)	30.8 ± 7.8	37.9 ± 14.0
	pH	7.37 ± 0.08	7.33 ± 0.09† *

* p < 0.01; † p < 0.001 compared to Day 1 $\dot{V}_E$ < 15 L/m Group **Conclusion**: The ARDS Network study data suggest that despite very high levels of $\dot{V}_E$ (> 18 L/min) demand, low V_T ventilation could be maintained in the majority of patients.

OF-01-115

INHALED NITRIC OXIDE: ONE-YEAR EXPERIENCE WITH A PROTOCOL FOR APPROPRIATE USE. Dean R. Hess PhD RRT FAARC, Daniel Chipman RRT, Robert M. Kacmarek PhD RRT FAARC, William E. Hurford MD. Massachusetts General Hospital and Harvard Medical School.

Nitric oxide, when administered by inhalation, is a selective pulmonary vasodilator. Over the past 10 years, there has been considerable academic and clinical interest in the use of inhaled nitric oxide (iNO) in the treatment of diseases associated with pulmonary hypertension and hypoxemia. Randomized controlled trials have reported benefit for the use of iNO in the care of newborns with hypoxic respiratory failure, and the FDA approved the use of iNO for this indication on December 23, 1999. However, randomized controlled trials to date have not shown a benefit for iNO in other diseases, and its use in these cases is off-label. Given the relative lack of evidence for off-label use of iNO and the expense associated with this therapy, we designed an institution-approval protocol for the use of iNO in our hospital. **Methods:** iNO for patient use is controlled by our Innovative Devices and Therapeutics Committee. This committee approved the use of iNO for newborns and for selected off-label indications. Off-label use was approved for the following indications: inhalation injury ARDS, lung resection ARDS, severe ARDS considered for ECMO, heart or lung transplantation, and acute right ventricular failure. Under each off-label indication, specific criteria were established for initiation of iNO therapy. Specific eligibility criteria were developed by consensus. If criteria to initiate therapy are met, a 30-min to 1-hr trial is conducted, and a decision to continue therapy is made based upon strict criteria. The use of iNO is monitored under the auspices of a Phase IV observational study with IRB approval. The respiratory care department was charged with screening all requests for iNO use, determining eligibility based upon institution-approved criteria, dispensing the gas, monitoring all aspects of utilization, and maintaining a database on its use and efficacy. Every request for iNO is prospectively reviewed by one of the respiratory care management team before therapy is initiated. Individual cases that fall outside of eligibility criteria are mediated, as necessary, by the co-chairs of the critical care committee. **Results**: For the first year of this protocol (April 1, 2000, to April 1, 2001), 25 newborns received iNO and all meet eligibility requirements. Eleven of these patients were receiving iNO prior to transfer (in most cases to be considered for ECMO). Initiation of iNO increased PaO_2 from a mean of 61 mm Hg to 154 mm Hg. ECMO was avoided in 44% of these patients, the mean length of iNO therapy was 2.2 days, and survival was 95%. For off-label indications, iNO was used in 47 patients (2 inhalation injury ARDS, 8 severe ARDS, 2 heart or lung transplantation, 36 right ventricular failure, 1 sickle cell disease); 85% met eligibility requirements. For those that did not meet eligibility requirements, iNO was approved after respiratory care and physician mediation. Of 48 trials (2 trials for 1 patient), 24 met criteria to continue therapy. In these trials, PaO_2 increased from 58 mm Hg to 101 mm Hg, and mean pulmonary artery pressure decreased fmm 41 mm Hg to 36 mm Hg with iNO. For off-label indications, the mean duration of therapy was 2.4 days. No safety concerns have arisen. Total program costs were 62% below the budget estimate for the first year. **Conclusions:** We have had excellent compliance with the protocol: 100% with neonatal use and 85% with off-label use. This has resulted in appropriate and cost-effective use of iNO in our hospital.

OF-01-142

EFFECT OF TUBE COMPENSATION (TC) VS PRESSURE SUPPORT (PS) ON TIDAL VOLUME (VT) & AIRWAY PRESSURES: A BENCH STUDY

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BACKGROUND: PS provides a constant pressure assist, regardless of patient effort, to overcome resistance of an artificial airway while TC provides a variable pressure assist level in direct proportion to patient effort. Clinically, it is unclear whether VT is augmented by high airway pressure seen using TC with small artificial airways. **STUDY QUESTIONS:** 1) What impact does TC have on VT, proximal, distal, and end-inspiratory pressures, compared to PS; and 2) What influence do artificial airways have on PS and TC? **METHODS:** Lung model: A computerized lung simulator (ASL-5000, Igmar Medical) was set to a single lung model with C=50 mL/cmH_2O, R=10 cmH_2O/L/S, RR=20, an inspiratory effort of −15 cm H_2O and settings resulting in an I:E of ~1:3.0. Ventilator settings: A PB-840 ventilator (Carlsbad CA) was set to PEEP=0 cmH_2O, FIO_2=0.21, and trigger= −1 cmH_2O. For PS breaths, flow acceleration=50% and expiratory sensitivity=10%. The ventilator was tested at PS=0, 5, and 10 cmH_2O, and TC=50 and 100%. Airways: Endotracheal tubes (ETT) of an ID of 6, 7, 8, and 9 mm were studied. The distal end of the ETT was attached to the lung simulator and the proximal end to the circuit wye with identical adapters. Measurements: Exhaled VT, peak pressure (P_{prox}) and end-inspiratory pressure (P_{ei}) from the ventilator were recorded. The simulator measured flow, volume, and pressure. These measurements were taken immediately distal to the airway tested, therefore airway pressure is considered to reflect 'carinal' pressure (P_{distal}). During pressure verification, P_{distal} read 1 cmH_2O > P_{prox} and P_{ei}. Data: Data from the ventilator and simulator for 10 breaths were analyzed for each data-set. **RESULTS:** As a reference, PS=0 with no airway attached resulted in a VT=435 mL. Table 1 shows the result on VT [in mL] and the percent boost in VT compared to PS=0 with the same ETT

	PS=0	PS=5	PS=10	TC=50	TC=100
ETT=6	278	326 (17%)	398 (43%)	303 (9%)	386 (39%)
ETT=7	329	386 (17%)	471 (43%)	350 (6%)	432 (31%)
ETT=8	367	435 (19%)	527 (44%)	373 (2%)	422 (15%)
ETT=9	381	453 (19%)	563 (48%)	387 (2%)	409 (7%)

Table 2 shows the effect on three pressures: P_{prox}, P_{distal} and P_{ei} (in cmH_2O).

	PS=0	PS=5	PS=10	TC=50	TC=100
ETT=6	2.7/4.0/2.5	6.2/7.2/6.2	11.0/10.3/11.0	4.4/5.7/3.3	13.0/7.0/5.9
ETT=7	2.9/5.2/2.8	6.5/7.3/6.4	11.0/11.2/11.0	3.7/4.7/3.7	8.8/5.7/4.6
ETT=8	3.3/4.4/2.9	6.7/7.2/6.6	11.1/11.5/11.0	3.9/5.3/3.5	5.9/5.3/3.5
ETT=9	3.5/4.6/2.9	6.5/7.3/6.5	12.0/11.8/11.4	3.9/6.0/3.5	3.9/5.6/3.5

CONCLUSIONS: 1) For a given inspiratory effort, VT is reduced as ETT size is reduced. 2) for a given ETT size, PS boosts VT in an incremental manner (similar %, regardless of ETT) and TC augments VT in a variable manner (less % boost in VT as ETT increases); 3) TC=100% augments VT > TC=50%, especially with small ETTs; 4) the high airway pressure noted at the ventilator (P_{prox}) using TC=100% with small ETTs is not present at the carina (P_{distal}) and therefore does not translate into a larger VT; and 5) with the PB-840, P_{ei} may better reflect P_{distal}. The clinical relevance of these findings remains to be determined.

OF-01-173

NONINVASIVE POSITIVE PRESSURE VENTILATION FOR "DO NOT INTUBATE" PATIENTS WITH ACUTE RESPIRATORY FAILURE: A PROSPECTIVE OBSERVATIONAL STUDY. Nella Altobelli, RRT; Guilherme Schettino, MD, Purris Williams, RRT; Jack Walsh, RRT; Khaled Sedeek, MD; Klaudiusz Suchodolski, MD, Dean Hess PhD RRT; Robert Kacmarek, PhD RRT. Massachusetts General Hospital and Harvard Medical School, Boston MA. **Background:** Noninvasive positive pressure ventilation (NPPV) has been used to treat patients with reversible causes of acute respiratory failure (ARF), or simply as a comfort maneuver, in terminal patients who refused endotracheal intubation (DNI). However few data is available about patient selection criteria and hospital discharge rate for these patients. **Objective**: To evaluate the outcome of DNI patients when submitted to NPPV to treat acute or acute on chronic respiratory failure of different etiologies. **Design**: A prospective observational study. **Setting**: An 800-bed tertiary university hospital. **Method**: The demographic, clinical, physiological, laboratory and hospital outcome data, as well as the ventilatory settings, of all DNI patients with ARF treated with NPPV were recorded on a daily basis. **Results**: From January to April 2001, NPPV was applied in 46 DNI patients (32 female) originally located in the emergency room (14%), intensive care units (18%) and general medical/surgical units (68%). In 56 % of the cases NPPV was applied for < 24hs and in 22% for a period between 1 to 3 days. PS/PEEP (80%) and CPAP (20%) were the utilized modes. The hospital survival rate was greater for patients with acute exacerbation of chronic pulmonary disease (9/13 cases) when compared to hypoxemic respiratory failure (4/20) (p=0.02). Cardiogenic pulmonary edema (11 cases) and post-extubation failure (2 cases) had a survival rate of 45 and 0% percent respectively. The hospital mortality was higher in the oncological patients (14/16 [87.5%]) when compared with the non-oncological (14/30 [47%]) patients (p< 0.01). Hypoxemic respiratory failure (12/16 [all died]) was the leading cause of ARF in the oncological.

The baseline data of the non-oncological patients are present in the table.

	Survived (16 cases)	Died (14 cases)	P value
Age	75.2 ± 12.5	80.2 ± 8.6	0.2
Acute Respiratory Failure Etiology			
Chronic Pulmonary Disease	8	4	
Cardiogenic Pulmonary Edema	4	4	
Hypoxemic Respiratory Failure	4	5	
Post-Extubation Failure		1	
Respiratory Rate/min	28.5 ± 8.5	27.4 ± 9.6	0.8
PaO_2 (mmHg)	96.7 ± 63.3	104.1 ± 57.9	0.8
$PaCO_2$ (mmHg)	63.8 ± 22.3	77 ± 31.1	0.2
pH	7.33 ± 0.08	7.29 ± 0.19	0.5
Glasgow Scale	13.6 ± 0.6	9.8 ± 1.1	0.005
APACHE II	18.2 ± 5.2	24.6 ± 5.5	0.005
SAPS II	33.5 ± 5.9	48.4 ± 11.5	0.001
Albumin (g/dl)	2.9 ± 0.7	2.2 ± 0.7	0.05

Conclusion: The use of NPPV should be encouraged in non-oncological DNI patients with reversible causes of ARF, particularly in those with acute exacerbation of chronic pulmonary disease. The outcome of oncological DNI patients with hypoxemic ARF treated with NPPV is extremely poor.

OF-01-180

CASE STUDIES: THE CLINICAL USE OF LOWER INFLECTION POINT DERIVED FROM A SLOW FLOW PRESSURE VOLUME LOOP

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Introduction: Current lung protective approaches to ventilator management include the Open Lung Technique and low tidal volume strategies. Determination of the lung opening pressure is a key component in opening the lung and keeping it open to avoid the recruitment/derecruitment injury to the alveoli. BiLevel is an enhanced form of Pressure Control Ventilation available on the PB 840 ventilators. Our lung protective approach to mechanical ventilation utilizes both low tidal volumes and the Open Lung Technique. We have developed our approach to utilize a ventilator generated slow flow Pressure Volume Loop to determine the Lower Inflection Point (LIP) and use this parameter to guide the setting of $PEEP_{Low}$ in BiLevel, thus avoiding repeated alveolar collapse. We then titrate the $PEEP_{High}$ (Inspiratory pressure) to deliver 7cc/kg IBW limiting alveolar stretch and avoiding barotrauma. The technique was incorporated into a Therapist Driven Ventilator Management Algorithm. The slow flow PV Loop was performed immediately after initial placement on the ventilator. The maneuver was performed after the administration of a short acting paralytic and the bedside staff was trained to determine the lower inflection point from the graphic display. Additional Inflection Point maneuvers were performed to guide ventilator management based on a PaO2/FiO2 ratio or if a significant change in the patient status was observed. **Experience**: We collected data over a six-month period of time on 100 patients (41 Medical patients and 59 Surgical patients) A total of 262 Slow Flow maneuvers were performed, with an average of 2.28 on medicine patients and 1.1 performed on surgical patients. The maximum performed on any patient was 14. There were three patients that the maneuver could not be performed on during initial ventilator application. The results of the initial Lower Inflection Points,$PEEP_{High}$ settings and Delta Pressure necessary to generate 7cc/kg IBW tidal volume are listed in the table below.

	Medical Patients			Surgical Patients		
	LIP	$PEEP_{High}$	Delta	LIP	$PEEP_{High}$	Delta
Mean	9.58	30.56	16	4.39	19.8	12.8
Min	5	22	12	12	12	7
Max	16	38	30	23	23	23
Mode	10	30	20	20	20	10

Discussion: The use of ventilation above inflection points has been introduced in the literature as a method to reduce lung injury. Our experience indicates that the use of a ventilator derived slow flow inflection point to guide ventilator management is a consistent methodology that can be safely used by Respiratory Therapists in a Ventilator Management Algorithm. Additional Studies are needed to determine the overall impact of this Bilevel Ventilation Strategy.

OF-01-181

P_{flex} CAN BE RELIABLY ESTIMATED FROM STATIC PRESSURE-VOLUME CURVES GENERATED WITH PEEP SET AT 5 cmH_2O

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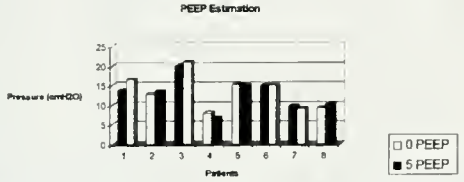
Introduction: It is possible that the determination of the lower "inflection point" (P_{flex}) on a static pressure-volume (static P-V) curve can be used to optimize positive end-expiratory pressure (PEEP) in patients suffering from acute lung injury (ALI/ARDS). The clinical utility of pressure-volume curve measurements depends, in part on the safety of the technique. Equally important is the elimination of inter-reader variability in the interpretation of P_{flex}. The purpose of this work is to determine whether P_{flex} estimation, based upon objective interpretation of static P-V curve measurement can be done with PEEP set at 5 cmH2O rather than 0 cmH2O. We hypothesized that the P_{flex} would not be different with PEEP set at 5 cmH2O compared with 0 cmH2O. **Methods:** Eight patients who presented to our SICU with PaO2/FiO2 ratio <300, mean lung injury score of 2.91, identified risk factors for ARDS, and the absence of exclusion criteria were identified as study participants. Exclusion criteria include any of the following factors: a history of chronic obstructive pulmonary disease, heart failure, or persistent chest tube leak. Following sedation patients were paralyzed and static P-V curves performed with PEEP set at 0 and 5 cmH2O, applied in random order. Static P-V curves were obtained using two commercially available ventilators and the valve method we have previously reported (respiratory rate 60, tidal volume 50cc, I:E ratio 1:5, and FIO2 80-100%). P_{flex} was calculated for each curve using a commercial computer program (STATA) and applying the formula published by Venegas. Data points were limited to those associated with zero flow. Inflection point estimates at the two PEEP levels for each patient were compared using the paired t-test **Results:** All patients that demonstrated a P_{flex} >5 cmH2O on 0 cmH2O of PEEP demonstrated a P_{flex} on 5cmH2O. STATA objectively predicted P_{flex} on 5 cmH2O within ± 2.68 cmH2O of P_{flex} predicted on 0 cmH20. Variability did not change whether the maneuver was performed on a PEEP level of 0 cmH2O or 5 cmH2O first. There was no statistical difference between the inflection point estimates at the two PEEP settings (p = 0.66).



Discussion: We have applied the work of Venegas to a baseline of 5 cmH2O in the ALI/ARDS population and have noted no significant difference compared with the results of P_{flex} initiated at 0 cmH2O. In a sub-group of the ALI/ARDS population, "charging" the patient circuit with PEEP prevents the flooding of flow sensors during the maneuver. In addition, any PEEP level that predisposes this patient population to alveolar collapse or flooding should be avoided in the interest of patient well being. With the exception of circumstances where P_{flex} is <5 cmH20, obtaining static P-V curves with PEEP set at 5 cmH20 appears to result in reliable P_{flex} estimates.

OF-01-186

IDEALIZED PRESSURE/TIME SCALAR ON HFOV

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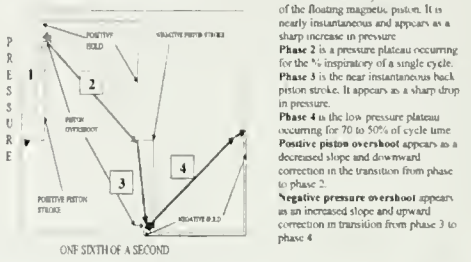
BACKGROUND: Qualitative changes in the shape of pressure/time scalars (P/T scalars) have been shown to correlate with changes in resistance and compliance during HFOV. The significance of these findings is dependent upon a clinician's ability to interpret changes. However, no standard for interpretation of these P/T scalars has been determined. The purpose of this work is to illustrate a potential standard approach for interpretation of P/T scalars in HFOV.

METHODS: A data base of P/T scalars was collected over a three year period consisting of HFOV waveforms captured from multiple models (bench, animal and patient). The data consists of analog P/T scalars obtained at the thermometer port of the circuitry. These measurements were converted to digital form 50,000 times per second (utilizing a Tektronix TDS 3032). P/T tracings were then analyzed to create an ideal construct.

RESULTS



Phase 1 is created by the forward stroke of the floating magnetic piston. It is nearly instantaneous and appears as a sharp increase in pressure.
Phase 2 is a pressure plateau occurring for the ⅓ inspiratory of a single cycle.
Phase 3 is the near instantaneous back piston stroke. It appears as a sharp drop in pressure.
Phase 4 is the low pressure plateau occurring for 70 to 50% of cycle time.
Positive piston overshoot appears as a decreased slope and downward correction in the transition from phase to phase 2.
Negative pressure overshoot appears as an increased slope and upward correction in transition from phase 3 to phase 4

DISCUSSION: We propose that an idealized P/T scalar provides an essential component of future investigation into factors affecting sub-tidal volume delivery. Our work contributes a tool not previously available in the management of HFOV. We find P/T scalars to be an adjunct that is both sensitive and specific to real-time clinical changes allowing an immediate response to potentially harmful alterations in the patient course. Further research is needed to establish the utility of P/T scalars outside of a research environment.

OF-01-187

EFFECTS OF AN IN-LINE IPV INTERFACE VERSUS ADJUSTABLE PEEP VALVE ATTACHMENT DURING INTRAPULMONARY PERCUSSIVE VENTILATION

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Introduction: Intrapulmonary Percussive Ventilation (IPV) is a therapeutic modality designed to mobilize and facilitate the removal of retained secretions, re-expand areas of collapse, increase deposition of aerosolized particles and improve gas exchange. IPV is routinely ordered in our institution for the treatment of atelectasis, and for mobilization of secretions in mechanically ventilated pediatric patients. Our current practice is to remove the patient from the mechanical ventilator, attach the IPV breathing circuit to the artificial airway, and percuss manually by depressing the remote switch. In patients requiring high mean airway pressures (MAP), we have observed episodes of acute desaturation when IPV is delivered in this manner. It is our hypothesis that removal of the patient from the ventilator causes significant reduction in PEEP, the loss of alveolar recruitment, loss of MAP, and desaturation. The purpose of this bench study was to compare the effects of maintaining peak IPV pressure and PEEP, while delivering IPV in-line with the mechanical ventilator to an alternative method using a spring loaded adjustable PEEP valve attachment to the IPV breathing circuit. **Methods:** Baseline IPV pressure settings (PIP and PEEP) were established by selecting predetermined pressures and verifying them on a Gould Brush 2400-4 channel chart recorder (Gould Corp.). IPV frequency was manually counted. In this laboratory evaluation, the IPV Percussionator Ventilator (Percussionaire Corp.) with its standard breathing circuit and interfacing assembly was attached to the inspiratory limb of an adult ventilator circuit at the patient wye on a Bird V.I.P. ventilator (BIRD Corp.). As an alternative to the in- line setup, an AMBU peep valve, (AMBU Inc.) was attached to the standard IPV breathing circuit at the exhaust port of the Phasitron assembly, for IPV delivery independent of the ventilator. Both setups were connected separately to a 4.0 endotracheal tube (10 cm long) attached to the Ingmar Adult/ Pediatric Test Lung Model (Ingmar Inc.) Baseline pressure (PEEP), and inspiratory pressures (percussions) were measured with a Gould Brush 2400-4 channel chart recorder during a high frequency/ low pressure IPV strategy of 200 bpm and pressure of 15 cm H_2O, as PEEP levels were increased from 0-20 cmH_2O in 5 cm H_2O increments. **Results**: The results from the of the actual IPV PIP and the system PEEP are given in the tables below:
Conclusion: IPV delivered via artificial airway with a stand-alone adjustable PEEP valve attachment was better able to maintain a desired pressure gradient (PIP-PEEP) than the IPV in-line ventilator setup. IPV with a PEEP valve attachment can be used to maintain adequate PEEP levels in clinical states requiring high PEEP.

OF-01-190

COMPARING WORK OF BREATHING (WOB) DURING CPAP AND PRESSURE SUPPORT (PS), WITH AND WITHOUT AUTO-TUBE COMPENSATION (ATC)

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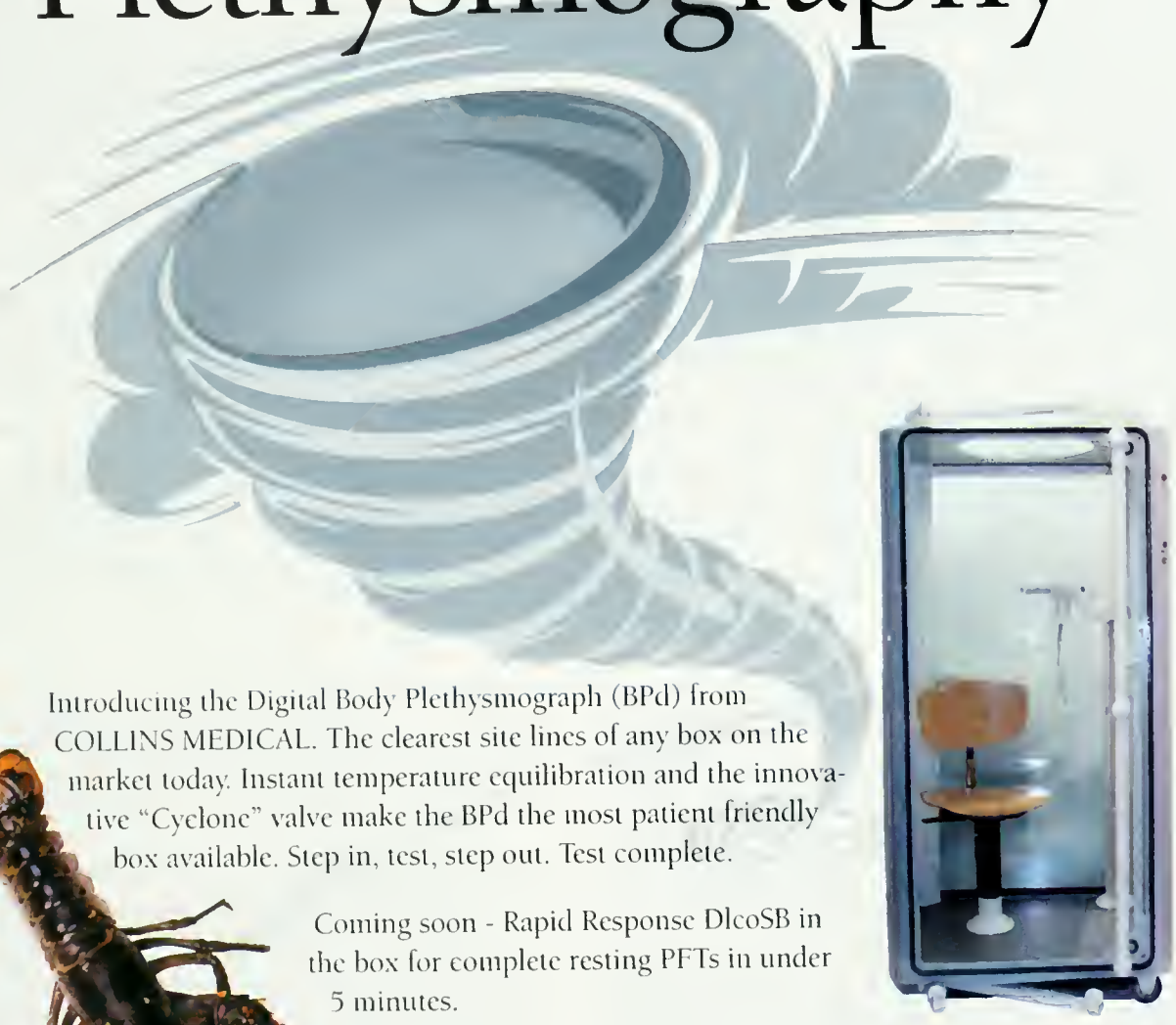
Background: ATC augments ventilator inspiratory flow rate $\dot{V}_I$ to achieve the proximal airway pressure target at the distal tip of the endotracheal tube (ETT), thus counterbalancing the imposed WOB of the artificial airway. Low to moderate levels of PS often are used for the same purpose. We compared the effects of ATC on WOB, V_T and peak $\dot{V}_I$ during CPAP and PS. **Methods**: A standard WOB lung model was constructed using a Michigan Instruments TTL set at a compliance of 27 mL/cm H_2O; powered by a Veolar ventilator set to create a V_T demand of 500 mL at a respiratory rate of 24 and a peak $\dot{V}_I$ demand of 50 L/m. The Drager E-2 treatment ventilator was set at CPAP of 5 cm H_2O and then with PS of 5 and 10 cm H_2O. The flow trigger was set at 5 L/m. We measured the WOB performed by the drive ventilator to displace the "patient" compartment (WOBc). WOBc approximated total imposed WOB (ETT + circuit). Experiments were done with ATC turned off and at 100% ATC compensation set to the corresponding ETT sizes used in the model (7.0 and 6.0 mm ID). Measurements were made with a BICORE CP-100 monitor; 10 breaths were used for analysis. Data was reported as mean ± standard deviation and analyzed using repeated-measures analysis of variance and Tukey-Kramer tests. Alpha was set at 0.05. **Results**: Adding ATC to CPAP increased peak $\dot{V}_I$ more than adding 5-10 cm H_2O of PS. CPAP with ATC reduced WOBc more than PS of 5 cm H_2O. For each level of PS, adding ATC increased peak $\dot{V}_I$ and substantially reduced WOBc at both ETT sizes. Only 3 comparisons were not statistically significant (*, †, ‡; p > 0.05).

ETT 7.0	$\dot{V}_I$(L/m)	V_T (mL)	WOBc (J/L)	% ↓WOB
CPAP	62 ± 1	581 ± 3	0.97 ± .01	
CPAP ATC	96 ± 1*	641 ± 6	0.46± .01	53%
PS 5	67 ± 1	630 ± 0	0.66± .02	
PS 5 ATC	97 ± 2*	712 ± 6	0.32 ± .01	52%
PS 10	77 ± 1	676 ± 5	0.38 ± .03	
PS 10 ATC ON	109 ± 2	766 ± 5	0.19± .01	50%
ETT 6.0				
CPAP	54 ± 0.7	552 ± 4	1.45 ± .02	
CPAP ATC	64 ± 0.7†	589 ± 3	1.07 ± .01	26%
PS 5	56 ± 0.5	585 ± 5	1.15 ± .01	
PS 5 ATC	65 ± 2†‡	630 ± 0	0.80 ± .02	30%
PS 10	59 ± 0.4	620 ± 0	0.80 ± .02	
PS 10 ATC ON	66 ± 0.6‡	642 ± 4	0.51 ± .01	36%

Conclusion: Adding 100% ATC to CPAP was more effective in reducing total imposed WOB than adding 5 cm H_2O PS, but not as effective as adding 10 cm H_2O PS. ATC was less effective in reducing WOBc when a small ETT size (6.0 mm ID) was in place, possibly because of less flow augmentation.

OF-01-197

Digital Body Plethysmography



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INTERNAL HOSPITAL OXYGEN BACKUP DELIVERY SYSTEM

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Background: Holmes Regional Medical Center is a full service 468-bed major medical center with a level II trauma center and a level II Neonatal Intensive Care Unit. Situated in Melbourne Florida, a coastal community, Holmes Regional is custom to external disaster threats such as hurricanes. With this in mind the current oxygen delivery system was evaluated to insure uninterrupted oxygen delivery to the entire hospital facility. Concerns were identified with the current supply tank, reservoir tank and delivery piping connections between the tanks and the facility. Would they be able to withstand a category 4 or 5 hurricane?
Method: It was then decided to create an alternative internal oxygen delivery system, which could be initiated, monitored and discontinued from within the facility. The oxygen riser diagrams were pulled from our plant operations department and determined that the facility could be back-fed from three entrance points. All three-entrance points were located within the facility on the first and second floor. It was then determined that liquid oxygen provided the greatest delivery amount and practical ease of use. Three manifolds were then constructed and installed at the three oxygen entrance points. Each manifold allowed for a manual switch to allow liquid oxygen to back feed into the internal oxygen delivery system. Each manifold contained six quick connections to connect to the cryogenic dewars.
Results: Once the manifolds were installed it was then time to test the system. Eighteen dewars were delivered in which six were placed by each manifold. Connections were made and the internal system was then allowed to back feed oxygen to fifty-five psi, (current external system was set at fifty psi). With the psi now at fifty-five psi, the external delivery system was no longer supplying the facility. The internal system was monitored for four hours and determined to discontinue and resume to the external delivery system. The test was considered a success.
Experience: During the testing exercise it was determined that the availability of eighteen liquid dewar tanks was limited. As with any external disaster other facilities would require oxygen back up tanks as well, thereby limiting the supply. It is our recommendation that the facility purchase and maintain its own dewar tanks to insure availability for outside gas companies to fill when needed.
Conclusions: Holmes Regional Medical Center has developed a way to insure the continuous delivery of oxygen during unexpected catastrophic interruptions.

OF-01-026

A Focus on Medication Errors and Missed Treatment as an Outcome Measure for Respiratory Care, Elizabeth Begley RRT MA CPHQ, Christopher Keeys PharD BCPS, Geoffrey Morgan RRT BS, Alfred Munzer MD, Zelick Stewartson RRT BS

Background:
Recent public concern surrounding "medication errors" has created both internal and external interest in looking at the topics of "missed medicated respiratory care treatments" and potential negative clinical outcomes associated with missed treatment. In response to recommendations by the Pharmacy and Therapeutics Committee at Washington Adventist Hospital, Takoma Park MD the Pulmonary Medicine Department created a process for capturing, categorizing, and reporting missed therapy.
Method:
Nationally the trend is moving toward the concept of well-defined definitions for various PI indicators with a centralized database, such as the JCAHO ORYX program or the Maryland Indicator Project. The concept behind a nationally established PI registry, is that common well-defined indicators can be used for comparisons and benchmarking of outcome data. In an effort to create a meaningful measure associated with missed therapy the Department of Pulmonary Medicine at Washington Adventist Hospital developed a set of defined PI categories for reporting and analyses of Respiratory Care Medication Errors and Missed Treatments.
Results:

	2000	1999
Total Occurrences	4%	6.65%
Missed Treatments / Total Treatments	4350 / 98,000	3100 / 91,176
Medication Errors	.5%	.89%
Medication Errors / Total Treatments	500 / 98,000	588 / 91,176
Total # Treatments Annually	98, 000	91,176

Conclusion
Based on the definitions and processes outlined the Pulmonary Medicne Department is in the process of establishing an internal database for benchmarking. Data base tracked and reported data for 2000 and have baseline aggregate data for 1999. The breakdown of the data based on the established definitions has allowed the department to focus our PI efforts, and we are now able to correlate "medication errors" with workload, employee performance and customer satisfaction data. The concept of the development of a national definition of "Respiratory Care Medication Errors" and "Respiratory Care Medication Occurrences" would be a progressive step for the Respiratory Care profession.

OF-01-031

RATE OF SUCCESS OF A NON-INVASIVE VENTILATOR PROGRAM

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BACKGROUND: Kaiser Permanente's West Los Angeles Medical Center is an acute care hospital serving the HMO's members on the west side of Los Angeles. In 1997, the medical center instituted an aggressive non-invasive ventilator program with the goal that between 10-20% of all mechanical ventilation would be delivered non-invasively. Patients were treated with non-invasive ventilatory techniques primarily in the hospital's telemetry unit and ICU, although some patients were initiated in the Emergency Department. METHODS: Lead RCPs attended a "train-the-trainers" educational program about non-invasive ventilation sponsored by an equipment manufacturer. The lead RCPs, in turn, trained the department's staff and instituted the program. Patients suffering from respiratory failure were offered non-invasive ventilation if they could cooperate with verbal commands, handle their own secretions, and had an intact gag reflex. To ensure adequate patient-ventilator interaction a trained RCP remained with the patient for the initial 45 minutes of therapy. RESULTS: In 1997, the program treated 52 patients (partial year data) and has expanded steadily since then. Patients using long-term non-invasive ventilation were excluded from the data. Adverse reactions were tracked and the only items reported were instances of mild facial rash or skin redness. The results are summarized in the follnwing table.

	Year		
	1998	**1999**	**2000**
# Non-invasive Pt's	62	126	130
Non-invasive days	182	370	425
Invasive Pt's	408	382	463
# Invasive days	1925	1166	2165
Total Mech V Days	2107	1536	2590
% Non-invasive	9%	24%	16%
# Intubated after NI Trial	6	22	27
Rate of Success	90%	83%	79%

EXPERIENCE: A well-implemented non-invasive ventilator program can offer carefully selected respiratory failure patients a safe treatment option with an acceptable rate of success. CONCLUSIONS: In order to avoid the well-known complications associated with invasive mechanical ventilation, our hospital pursued the non-invasive ventilation option. A successful implementation program can increase an organization's acceptance of new treatment strategies for respiratory failure.

OF-01-036

RESPIRATORY THERAPY INITIATIVE TO DECREASE GENERAL NEBULIZER UTILIZATION IN A NOT-FOR-PROFIT HOSPITAL

Therese M.Conner, PhD[1], Ron Boultinghouse, MBA[1], James Davis, MSN[1], Frank Mazza, MD[1], Shad Pellizzari RRT[1], KC Cerny, PhD[2] 1:Seton Healthcare Network, Austin, TX; 2: Management Information Analysis, Austin, TX.

BACKGROUND: Studies have shown that opportunities exist to decrease nebulizer treatments among patients who do not derive clinical benefit from administration. Our RT Department developed and implemented a general nebulizer use protocol on a large scale in 1999 in an attempt to standardize respiratory care and encourage the RT's participation in assessing the patient's respiratory care needs. METHOD: After internally publicizing the RT initiative to physicians and staff, trained RT assessors identified appropriate patients and offered voluntary protocol participation to physicians requesting respiratory treatment. A severity scale was developed to daily assess patient needs and to wean nebulizer use as the patient's condition improved. Data were collected via network database and chart review for patients with discharge dates between 7/99-11/00. Trending and applicable statistics were performed. RESULTS: Data were collected for 4,364 inpatients receiving at least one nebulizer treatment, of which 1,184 (27%) were on protocol. Natural log transformation was conducted on non-normal data. Patients on protocol were older (72.0 y/o), compared to non-protocol patients (67.2 y/o) [t=7.22, df=4362, p=0.00] but APR-DRG severity scores were not statistical different among larger diagnostic subgroups. Regression analysis showed lower average nebulizer use per day among protocol patients [t=-8.8, p=0.000], resulting in an average reduction of 5.77 nebs per patient stay. Protocol patients had an average monthly reduction of $31,192 in FY 2000 charges and an average monthly range of $3,244-3,845 in supply/labor cost savings. CONCLUSION: While protocol use is voluntary, protocol patients have consistently used less nebulizers, resulting in lower charges and costs. Future research will ascertain impact on patient outcomes within major diagnostic categories.

OF-01-037

HOMECARE COMPANIES AS TREATMENT CENTERS FOR CASUALTIES OF CHEMICAL OR BIOLOGICAL WEAPONS ASSAULT

Chris Cella, RRT, Peter Katona, MD, APRIA Healthcare, Redmond, WA.

There are approximately 8000 homecare offices located throughout the United States. In the event of a significant release of chemical or biological weapons in a major metropolitan area, hospitals would quickly be filled beyond capacity. Home healthcare organizations typically have bulk quantities of liquid and gaseous oxygen, oxygen delivery devices, pressure and volume ventilators available. Larger companies may also have onsite pharmacies, durable medical equipment, infusion and enteral supplies, RN's, RCP's, and other medical professionals. Warehouse space is typically abundant, and would be well suited to triage casualties.

Potential agents include Anthrax, Brucellosis, Cholera, Glanders, Plague, Tularemia, Q Fever, multiple viruses, Smallpox, Venezuelan Equine Encephalitis, Viral Hemorrhagic Fevers, Botulism, Staphylococcal Enterotoxin B, Ricin, T-2 Mycotoxins, chemical nerve agents, Cyanide, Vesicants, Nerve, Pulmonary and Incapacitating agents.

The medical professionals, including RCP's are already familiar with the equipment necessary to help sustain patients in any setting. Work needs to be done on local and national levels, helping network individuals to collaborate resources in the event of potential future catastrophes.

OF-01-057

PREVALENCE AND PERCEPTIONS OF IMPLEMENTATION OF PATIENT CARE PROTOCOLS BY RESPIRATORY THERAPISTS IN ARKANSAS

Ron Cothran, Jr., BS, RRT, CPFT, Pueblo Community College, Pueblo, Colorado. Theresa Gramlich, MS, RRT, Mildred Savidge, PhD. University of Arkansas for Medical Sciences, Little Rock Arkansas.

Background: Evidence strongly points to the efficacy of implementation of patient care protocols (PCPs) by respiratory therapists. However, data concerning the prevalence and perceptions of respiratory therapists' PCP implementation in Arkansas was lacking. The purpose of this study was to determine PCP prevalence and perceptions of barriers to implementation and benefits in Arkansas hospitals.

Method: A qualitative survey instrument was developed to determine the use and distribution of patient care protocols used in Arkansas hospitals, as well as implementation responsibility, barriers to implementation, and types of outcomes. The survey instrument was then pilot tested for reliability by 6 acute care facilities in Colorado known to be using PCPs. We then distributed surveys to respiratory care departments of the entire population of hospitals that were members of the Arkansas Hospital Association.

Results: We mailed the survey to 78 respiratory care departments. Of these, 38 (49%) completed and returned the survey. Three of four respondents reported PCP implementation. Non-critical care areas were the most prevalent setting for PCPs; they were also operational in emergency departments and intensive care units. These findings were well distributed across the state. Perceived barriers to implementation were insufficiencies of physician support and respiratory therapists' education level, proactivity, self-efficacy, and time. Perceived benefits were improvements in the following: patient care, length of stay, allocation of staff and services, hastened weaning from mechanical ventilation, staff self-worth, and collaboration between respiratory therapists and physicians.

Conclusions: Among our study sample, respiratory therapists have commonly implemented PCPs in Arkansas. Perceived barriers were related to lack of physician support and respiratory therapists' insufficiencies. Perceived benefits included enhanced patient care and respiratory therapists' job satisfaction. Limitations to this study included a return rate less than 100%, and possible Hawthorne bias from RCPs who answered survey questions. Overall our data suggests a need to improve the education, confidence, and assertiveness level of RCPs in the implementation and usage of patient care protocols.

OF-01-075

CRITICAL PATH ANALYSIS OF A CYSTIC FIBROSIS CARE PATH IDENTIFIES PROCESS IMPROVEMENT OPPORTUNITIES

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Background: Network diagrams and critical path analysis are used as resources to manage complex projects. These project management tools show process interdependencies, identify rate limiting steps and streamlining opportunities, and estimate a time line for project completion. We used these tools to construct a care path to improve the care of patients (≤ 18 years) with cystic fibrosis hospitalized for an acute pulmonary exacerbation. We hypothesize that the care path length of stay (LOS) predicted by the critical path analysis would match actual patient data and the analysis of key patient care processes in the critical path could be used to identify performance improvement areas. **Methods:** Four key patient care processes were identified. Two were streamlining opportunities (physician order entry and initial antibiotic administration time). The remaining were rate-limiting steps (obtain patient sputum sample and report culture and sensitivity results). Standard times were estimated from physician and staff expert opinion (order entry time, time to obtain sputum specimen). Current hospital pharmacy and laboratory time standards were used as standards for initial IV antibiotic administration time and culture and sensitivity reporting time. A network diagram was constructed to map patient care from the time of admission to the completion of the key care processes. The duration of the critical path, in days, was the projected LOS. A care map was constructed to standardize the care path's laboratory tests, and diagnostic and therapeutic modalities over that projected LOS. The care path was implemented and data prospectively gathered from January 1, 2000 to December 31, 2000. Key process and outcome (LOS) data were collected into a database and analyzed using one-sample *t*-tests, where the specified test value was set to the projected standard times for each key process and the projected LOS from the care path model. Statistical significance was set at $p < 0.05$. **Results:** Fifty-eight patients meeting the care path criteria were treated over the 12-month period. The table below compares the projected and actual measured mean times (SD) for each key process and the LOS for the care path.

Key Care Processes	Projected	Measured Value	p Value
Physician orders entered and activated	1 hr	0.95 hrs (0.77)	0.59
Initial IV antibiotics administered	2 hrs	3.12 hrs(1.36)	< 0.001
Sputum specimen obtained	2 days	1.27 days (2.4)	0.03
Culture and sensitivity results	5 days	7.2 days (3.73)	< 0.001
Length of stay	9 days	10.03 days (6.3)	0.22

The LOS and three key processes predicted by the critical path matched or were less than actual patient care data. However, two key steps of the critical path (initial IV antibiotic administration and culture and sensitivity results) exceeded the projected standards, and present opportunities for additional improvement. **Conclusions:** A well designed care path, using network diagrams and critical path analysis, can predict actual patient care outcomes and provides a mechanism to identify, measure and improve key patient care processes.

OF-01-102

IMPACT OF A RADIO FREQUENCY MANAGEMENT INFORMATION SYSTEM ON THE PROCESS AND TIMING OF PROVIDING RESPIRATORY CARE SERVICES.

Lucy Kester, MBA, RRT, FAARC, Doug Orens, RRT, MBA, James K. Stoller, MD. The Cleveland Clinic Foundation, Cleveland, Ohio.

BACKGROUND: Although radio frequency (RF) systems have proliferated with the intention of simplifying the delivery of care in many clinical settings, little information is available regarding the impact of such RF systems on the actual delivery of patient care. Having used a handheld management information system in our Respiratory Therapy Section for 15 years, we wished to assess the impact of an RF system versus our existing handheld device-based system on the delivery of respiratory therapy (RT) services. Presently, the sequence of events in our institution for placing RT orders is as follows: 1. A physician writes an order for an RT treatment or an RT consult, 2. A unit secretary transfers the order to a computer order entry system and places a copy of the printed orders in the unit's RT notebook, 3. The order entry system interfaces with the RT Section management information system (ClinVision, Nellcor/ Puritan Bennett, Carlsbad, California) thereby "notifying" RT of the order, 4. Therapists pick up "new notifies" in the RT Section at the beginning of their shift and at mid-shift. Prior to making assignments for the next shift, all therapists must be paged to report the number of new orders added to the workload as well as orders that have been discontinued.

METHODS: A single nursing unit dedicated to pulmonary and ENT care was selected for the RF trial. Baseline (pre-RF) data were collected over three separate 1-month intervals (Sept.'97, Feb.'99, Feb.'00) with the main outcome measures being the time between notification of RT orders and the time treatments were started and RT consults were completed. Activities required for making assignments for the next shift were manually timed. Starting 6 weeks after therapists (3 to 4 per shift) were trained to use the RF system, similar data were collected while using the RF system for two 1-month intervals (Feb. and Mar. '01).

RESULTS: Table 1 presents outcomes using the handheld (HH) vs. the RF systems.

TABLE 1. (time in hours)	**HH System**	**RF System**	**P value**
Number of patients with RT orders	195	149	
Mean time (± SD) from notify to start of therapy	4.7 (±8.8)	3.1(±6.7)	0.026
Number of patients who waited >8 hrs for therapy	32 (16.4%)	14 (9.4%)	0.083
Number of consult evaluations	139	82	
Mean time (± SD) from notify to consult eval.	10.0 (± 30)	2.2 (±2.4)	0.003
Number of patients who waited >8 hrs for eval.	26 (18%)	3 (3.7%)	0.013
Shift Assignments (time in minutes)	**HH System**	**RF System**	**Δ (min)**
Calculating and assigning workloads	31.6	29.6	- 2
Time for handheld upload	28.3	0	- 28.3
Time for down-loading handheld computers*	10.0	0	10
Time for printing reports (*done during printing)	11.7	14	+ 2.3
Total time for shift assignment	**81.6**	**43.6**	**- 38**

CONCLUSIONS: Compared with a handheld system, use of a radio frequency system for processing respiratory therapy orders was associated with several benefits. 1. Reduced interval between receipt of an order for RT and delivery of the treatment, 2. Reduced interval between request for and completion of a RT consult, 3. Reduced proportion of patients for whom the interval between the order and a consult evaluation exceeded 8 hours, 4. Shortened time for supervisors to make shift assignments. These results invite further assessment of the clinical benefits associated with accelerated delivery of respiratory therapy services.

OF-01-110

LONG-TERM FOLLOW-UP OF PATIENTS IN A HOSPITAL-BASED WEANING UNIT. Richard D. Rice, B.S., RRT, James K. Stoller, M.D. The Cleveland Clinic Foundation, Cleveland, Ohio.

Background: Because little attention has been given to long-term outcomes of patients in hospital-based ventilator weaning units, we undertook this assessment of outcomes of patients discharged from the **R**espiratory **S**pecial **C**are **U**nit (ReSCU) of the Cleveland Clinic Hospital. Specifically, the current observational study evaluates the 5-year survival rates and disposition status of patients cared for in our ReSCU between August 22, 1993 and June 1, 1996. **Methods:** The ReSCU consists of 6 private beds on a pulmonary specialty ward. Features of the unit include non-invasive monitoring (e.g., continuous pulse oximetry, end-title capnometry, and ventilator alarms) with signal output at each bedside and at a central monitoring station. The unit is staffed by nurses with specific pulmonary rehabilitation expertise and 24-hour respiratory therapy supervision. Ongoing prospective data collection in the ReSCU includes monitoring weaning success, demographic features, hospital discharge status, and discharge disposition. Long-term outcomes were ascertained using review of hospital medical records and direct inquiry. **Results:** In this interim study report, we establish 5-year outcomes for 80% of the 124 unique patients in this cohort. Between August 22, 1993 and June 1, 1996, 150 individuals were admitted to the ReSCU, 6 repeatedly on separate hospital admissions. Seventeen percent (n=26) died during hospitalization, while 83% were discharged from the index hospitalization. Of these 124 hospital survivors, 5-year outcome year status is currently known for 80% (n=99), the remaining data still being sought in this ongoing study. Of the patients discharged, 11% (n=14) were known to have died within 1 month, while 47% (n=58) died within 1 year. Cumulative mortality rates were: 2 years 56% (n=70), 3 years 63% (n=78), 4 years 68% (n=84), and 5 years 73% (n=90). Five-year mortality rates considered by year of ReSCU admission were for 1993 82%, for 1994 76%, for 1995 78%, and for 1996 52%. Of the patients already weaned at the time of hospital discharge (n=94), 72% (n=68) died within 5 years. **Conclusion:** 1. In this population requiring prolonged inpatient ventilatory support, moderately high acute mortality rates are consistent with other series and are in keeping these patients' high severity of illness. 2. In this as yet incomplete analysis of longer-term follow-up rates, 5-year survival rates are low, with progressively increasing mortality in successive 1-year follow-up intervals. 3. At the same time, it must be recognized that the current incompleteness of follow-up rates may introduce bias into this analysis, depending on the vital status of patients whose follow-up status remains unknown. Ongoing efforts are directed at ascertaining complete follow-up of this cohort.

OF-01-123

EARLY IMPACT OF IMPLEMENTING AN MDI PROTOCOL FOR PEDIATRIC PATIENTS

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Overview: UCSD has incorporated several patient driven protocols to improve the utilization and efficiency of respiratory care delivery in the adult populations. The implementation of PDPs in 1993 resulted in a 40-50% reduction in bronchial hygiene interventions. In addition, we observed an increase in the use of Metered Dose Inhalers (MDIs) from less than 10%, to greater than 65% of total aerosol delivery. The MDI protocol program was expanded in June of 2000 to incorporate the pediatric population, ages 5-12, with the objective to ensure care was appropriate, that clinical objectives were achieved and that any potential to reduce expenses was realized. To assess the degree of early success we evaluated changes in the % of total aerosols delivered by MDI. **Methods:** The respiratory care department developed an MDI protocol to meet the unique needs and considerations of patients in the 5-12 age group. Once consensus was reached by members of the Pediatric Division Medical Staff, staff and faculty were trained on the use of the protocol, and the protocol was implemented. Data was extracted from the department information system to determine the number of patients receiving aerosolized medication and the method of administration before and after implementation of the protocol. **Results**: Data was collected on 6,557 treatments given over a one year period prior to protocol implementation and compared to 1,568 treatments given over a three month period after protocol implementation. The use of MDIs increased from 12% to 20% of total bronchodilator delivery. **Discussion:** Our experience demonstrates that an MDI protocol for Pediatric patients can be successfully implemented and that patients can be successfully transitioned from nebulizers to MDIs. In only three months the overall utilization of MDIs in the pediatric population increased by 67%. Difficulties encountered in transitioning to MDIs in the pediatric population included the lack of information from drug manufacturers for use in patients under 12 and the difficulty in getting small children to perform breath maneuvers that optimize deposition when using an MDI. In the months ahead we will continue to monitor the transition to MDI and the impact on department cost and patent outcomes.

OF-01-152

PATIENT DRIVEN PROTOCOLS IMPACT ON COSTS OVER AN 8-YEAR PERIOD

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Overview: In June of 1993 we implemented Patient Driven Protocols (PDPs) to increase the efficiency and benefit of respiratory care in our medical center. Over a one year period, 13 protocols were implemented throughout the medical center and total routine bronchial hygiene treatments (aerosolized medication and chest physiotherapy) decreased from over 7,000 to 2,948 per month without adversely effecting patient outcome. The decrease in treatments was associated with a $150,000 reduction in year-end direct variable expenses and a decrease cost per respiratory patient from $493 to $401. The ability to sustain such gains is an important consideration in continuing and expanding the program. We compared ongoing treatment and cost trends to assess the long-term impact of the program. **Methods**: Data from 7/93-7/94, the first year of protocols, was compared with recent year end data from 7/99-7/00. The number of aerosol and chest physiotherapy treatments provided and number of respiratory patients were obtained from the Respiratory Care Management Information System (RCMIS), in which all treatment activity is entered. Department costs were taken directly from the hospital budget reports to reflect actual expenses and inflation adjusted at a rate of 4% per year. The configuration and content of both the RCMIS and budget reports had not changed over the comparative period. **Results:** The average number of bronchial hygiene treatments given per month for the 99-00 period was 2,880. Bronchial hygiene treatments originally decreased from over 7,000 per month to 2,948 and have been consistently under 3,000 per month since the program was fully implemented. The actual cost per respiratory patient for the 99-00 was $389 in 2000 dollars and adjusted to $305, to reflect 1994 dollars and compare to the original reduction to $401. **Discussion**: The significant decrease in bronchial hygiene treatments observed in the early implementation of PDPs has been maintained. The cost per respiratory patient has also continued to decrease over this period. The decreases in the number of treatments provided and the decrease in cost per patient have been achieved without adversely effecting outcomes. The greater reduction in cost per patient may be attributed to the expansion of the program over the 8-year period to incorporate over 25 protocols directed at high cost high volume services. The PDP program continues to be an effective in reducing treatments that are considered unnecessary and avoiding associated cost.

OF-01-153

DEVELOPMENT OF A PRODUCTIVITY MANAGEMENT SYSTEM FOR PULMONARY FUNCTION

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Overview: The AARC Uniform Reporting Manual (URM) for Diagnostic Services provides activity time standards and approach to develop productivity management systems for PFT Labs. There are however, many support activities in the URM that do not include time standards, as well as activities that cannot be directly captured through patient charge systems. In such cases, each facility must assess the nature and duration of these activities and incorporate these "non-allocated" times in their productivity monitoring and reporting systems. We describe a method of collecting information to identify the nature of activities and their associated duration to develop a productivity management tool for PFT.

Methods: We elected to have staff complete a daily activity record. The activity record facilitated the entry of an activity description/type, the time it started, the time it ended, and related comments. Detailed instructions were provided to staff to insure constancy in making entries. Each staff member maintained activity entry over a 2-week period to account for a total of 93 workday profiles and over 600 activity entries. Data was analyzed to identify the type support task and the amount of time a PFT technician spent performing the activity.

Results:

Activity	Total Time per 8 Hour Shift
Caliberation and Prep	25
Equipment Troubleshoot/Service	10
Pagers/Phones/Communications	10
Inservice/Meetings	10
Housekeeping/Equipment Cleaning	15
Customer Service/Client Support	20
Document/File Production	45

Discussion: By identifying the time spent in support activities and utilizing treatment time standards as outlined in the AARC URM, we developed a productivity management tool for PFT. The system has provided for an assessment of service demand and a new tool to better assess staffing requirements for new programs, to justify staff, and to flex and cross utilize staff with changes in work demand.

OF-01-154

A VENTILATOR MANAGEMENT PERFORMANCE IMPROVEMENT PROGRAM

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BACKGROUND: An improvement team composed of Respiratory Care management, staff therapists, and medical director was formed in 1999 to determine improvement opportunities for adult mechanical ventilation (MV). The purpose of this abstract is to present an overview of the improvement project process. **METHODS:** A macro-flowchart identified 8 major time points associated with MV: 1) MV initiated, 2) ventilator settings suggest a wean assessment (FIO$_2$ ≤0.5, PEEP ≤5 cm H$_2$O, VE ≤15 L/m); 3) initial wean assessment done; 4) patient ready to begin weaning (meets #2 criteria and MIP ≤-20 cm H$_2$O, f/VT <105); 5) wean begins, 6) patient ready for MV to stop or extubation (meets #4 criteria and can protect airway, successful spontaneous breathing trial (PS ≤5 cm H$_2$O, CPAP ≤5 cm H$_2$O), minimal secretions, stable hemodynamics, acceptable ABGs); 7) patient extubated or MV stopped, and 8) time of reintubation or initiation of other support within 48 hrs. Type of intervention noted. ICU MV-related outcome was noted. Data was collected by the bedside respiratory therapists. Thresholds were established for the following segments: 1) 4-hrs from when ventilator settings suggest an assessment until it was done (Gap 1); 2) 4-hrs from when patient was ready to begin weaning until it started (Gap 2); and 3) 1-hr from when patient was ready to be extubated/stop MV until it was accomplished (Gap 3). Perceived reasons for deviation from thresholds for Gap 1 & 3 were collected. **RESULTS:** 1948 patients were monitored from 7/1/00 through 6/30/00. The thoracic ICU accounted for 41% of the patients, while the remaining 59% were associated with our other ICU's (surgical=20%, medical=15%, trauma/burn=12%, neuro=8% and coronary=4%). Aggregate (all cases) duration of ventilation was 72.9 ± 127 hrs (median=21.6 hr). Duration [in hrs] of Gap 1=18.3 ± 41.1 (7.0); Gap 2=3.1 ± 18.7 (0); and Gap 3=7.34 ± 31.9 (0.8). Percent of patients and perceived reasons for exceeding a gap threshold are: Gap 1=54% (44% sedation, 14% time of day, 14% unstable patient, 16% unknown, 12% other); Gap 2=8.4% (reasons not part of collection tool); and Gap 3=34% (25% MD availability, 15% MD decision, 12% airway, 8% time of day, 19% unknown, 21% other). Cause and effect diagrams were generated for each of the major segments of MV using the gap information and brainstorming techniques. An action plan was developed to address items within our control. Survival curves (SC) demonstrated a descending stair-step pattern in several MV segments, indicating major progress every 24 hrs. SCs also showed that when the initial set of parameters were obtained, 65% of the patients were ready to wean and that the RCP immediately began the wean 70% of the time. In addition, 6.4% of the patients did not stay off MV for 48 hours. Of those requiring support, 78% were reintubated, 7% used NPPV, 6% used trach-BiPAP, and 5% had a tracheostomy and were placed back on MV. ICU outcome showed that 85.6% stayed off MV, 12.1% expired, 1.1% were discharged on MV or BiPAP, and 1.3% were classified as 'other'. Unit specific reports of the initial findings were shared with each ICU medical director and nurse managers. Strategies were developed to improve each major segment of the MV process, including: a generic wean protocol, multiple MV and extubation policy changes, development of a RC care-plan tool, and RCP inservices. **DISCUSSION:** Continued assessment and re-evaluation will provide an opportunity to examine the impact of protocol changes on duration of MV in our adult population.

OF-01-170

RESULTS OF A VENTILATOR MANAGEMENT IMPROVEMENT PROGRAM

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BACKGROUND: A performance improvement team was formed in 1999 to determine improvement opportunities for adult mechanical ventilation (MV). The purpose of this abstract is to present a before and after comparison of changes to the MV process. **METHODS:** Eight major time points of the MV process were identified: 1) MV initiated, 2) ventilator settings suggest a wean assessment; 3) initial wean assessment done; 4) patient ready to begin weaning; 5) wean begins, 6) patient ready for extubation or MV to stop; 7) patient extubated or support stopped; and 8) time of reintubation or initiation of other support within 48 hours. Data was collected by the bedside respiratory therapist. Thresholds were established for the following segments: 1) 4-hrs from when ventilator settings suggest an assessment until it was done (Gap 1); 2) 4-hrs from when patient was ready to begin weaning until it started (Gap 2), and 3) 1-hr from when patient was ready to be extubated/stop MV until it was accomplished (Gap 3). Unit specific reports of the initial findings were shared with each ICU medical director and nurse managers. Strategies were developed to improve each major segment of the MV process, including: a generic wean protocol, multiple MV and extubation policy changes, development of a RC care-plan tool, and RCP inservices. Before implementing the changes, 12 months of data was collected. Six months were allowed to implement changes between measurement periods. The results presented compare the same 6-month period: January through June of 2000 (pre) vs 2001 (post). **RESULTS:** Data was gathered on 1102 pre-change and 1196 post-change patients. The duration of MV was 75.6 ± 135.6 hr (median=22.1 hr) for pre and 66.8 ± 128.6 hr (median=18.1 hr). The table shows the duration (in hrs) of various segments of the MV process and the time points used to calculate each segment in parenthesis.

Segments of the MV process	Pre (n=1102)			Post (n=1196)		
	Mean	SD	Median	Mean	SD	Median
1-Begin MV to ready for parameters (2-1)	13.1	40.2	2.1	13.9	62.3	1.9
2-Ready for parameters until done (3-2)	20.9	48.1	7.8	16.7	41.9	6.2
3-Initial parameters to ready to wean (4-3)	9.1	32.2	0	8.3	27.4	0
4-Ready to wean until begin wean (5-4)	3.1	16.7	0	2.6	13.4	0
5-Begin wean until ready to extubate (6-5)	19.0	65.8	0.6	18.0	69.0	0.4
6-Ready to extubate until done (7-6)	4.8	17.3	0.8	4.1	15.1	0.8

The percent of patients exceeding the thresholds for Gaps 1-3 (pre vs post) are: Gap 1=54.3% vs 51.6%; Gap 2 =7.6% vs 5.9% and Gap 3=32.0% vs 30.6%.

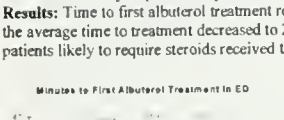
DISCUSSION: The median time of segments 3&4 of 0 hr indicates that when initial parameters are taken, a majority of patients are immediately ready to begin weaning and the wean process is initiated. Although there appears to be a trend toward reducing the overall duration of MV and the duration of most segments of the process, we are unsure how these actual times relate to predicted times based on the severity of illness. Comparing the actual times against predicted times, based on a predictive model for duration of MV, would help clarify whether improvement has indeed been made. The wide variety and severity of patient illness results in a large SD, which may obscure significant changes. Further analysis of sub-populations may identify such changes.

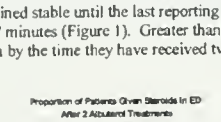
OF-01-171

USE OF AN EVIDENCE-BASED CLINICAL PRACTICE GUIDELINE TO ENHANCE PATIENT CARE AND IMPACT PARENT SATISFACTION IN A PEDIATRIC EMERGENCY DEPARTMENT (ED).

Scott Pettinichi, M Ed, RRT, Mary Pat Alfaro, MS, Kate Rich, BS, Uma Kotagal, MBBS, MSc

Background: Evidence Based Clinical Practice Guidelines (EBCPG) have been in place at Children's Hospital Medical Center since 1996. During 1998-99, we developed and implemented an EBCPG for the acute exacerbation of asthma. The goals for treating an asthma exacerbation are correction of significant hypoxia, rapid reversal of airflow obstruction, and to decrease the likelihood of recurrence. The guideline recommendations to achieve these goals are to promptly start main therapies (beta2-agonists and steroids) after a brief evaluation and assessment of severity by a respiratory therapist in the Emergency Department.
Methods: We reviewed the ED records of 25% of all patients with a discharge diagnosis of asthma between 9/98 and 6/00 to capture medication administration information relative to the time of arrival in the ED. Those treated with two or more beta2-agonist treatments were included in the analysis to capture the moderate to severe asthmatic population. The ED set a goal of treating every moderate to severe asthmatic with a beta2-agonist within 30 minutes of arrival. During the 1999-2000 guideline-monitoring phase, we conducted a telephone satisfaction survey of parents of patients who were seen for an acute exacerbation of asthma.
Results: Time to first albuterol treatment remained stable until the last reporting period when the average time to treatment decreased to 23.7 minutes (Figure 1). Greater than 80% of patients likely to require steroids received them by the time they have received two albuterol




Proportion of Patients Given Steroids in ED After 2 Albuterol Treatments
% Receiving Steroid After 2 Albuterol Treatments in ED
% Receiving Steroids in ED

treatments (Figure 2). Parents whose child received an albuterol treatment within 30 minutes of arrival to the ED were significantly more likely to report that they were very satisfied with care than parents whose child did not receive an albuterol treatment within 30 minutes (85% vs. 33%, p<0.003).
Experience: Based upon these results, not only are guideline recommendations for rapid treatment important from a medical standpoint, but rapid treatment enhances parent satisfaction with the visit. Results from parent surveys have been shared with the ED staff. We are continuing to monitor the time to treatment and use of steroids in the ED.
Conclusion: Process improvement strategies should focus on incorporating evidence based guideline recommendations to improve quality of care and enhance parent/patient satisfaction.

OF-01-175

THE IMPACT OF A RESPIRATORY THERAPY CONSULT SERVICE ON EMPLOYEE SATISIFICATION.

Douglas K. Orens, RRT, MBA, Lucy Kester, MBA, RRT, FAARC, James K Stoller, MD. The Cleveland Clinic Foundation, Cleveland, Ohio.

Background: Based on evidence of efficacy, respiratory care protocols have been implemented widely. A Respiratory Therapy Consult Service (RTCS) was introduced at the Cleveland Clinic Foundation (CCF) in February, 1992 and continues to be part of routine respiratory care practice at The Cleveland Clinic Hospital. To examine the impact of a RTCS on employee satisfaction, we assessed two issues in our Section of Respiratory Therapy (RT): 1. Employee turnover rates before and after introduction of the RTCS, and 2. Therapists' satisfaction working in a Section in which a RTCS has been in longstanding use.
Methods: Employee turnover was calculated before implementation of the RTCS starting in 1987 and has been determined annually since. The percentage of turnover was calculated by dividing the number of vacancies that occurred within the RT Section each year by the total FTE complement. Also, to assess therapists' satisfaction, an employee survey was distributed to the respiratory therapy staff during November 2000. The survey consisted of 10 questions that addressed the therapist's overall level of satisfaction about working at an institution that has a RTCS. Items were ranked on a Likert scale from 1 through 5, where 1= very little, and 5 = very much. Specific questions assessed therapists' satisfaction with their RT careers and the RTCS.
Results: Employee turnover was lower since implementing the RTCS than before. Specifically, between 1987 and 1992 (when the RTCS was begun), the annual rate of turnover was 14.9% (9.7 FTEs ± 3.96 SD, range 6 – 16 FTEs), and the average number of staff over this period was 65.3 FTEs (range 63.5 – 71.5 FTEs). Since implementing the RTCS, the mean rate of turnover (1992 to 2000) was 9.% (7.7 FTEs ± 3.0 SD) and the average number of staff has been 84.5 (range 71.5 – 95.5). Ratings regarding therapists' career and job satisfaction were based on 49 surveys of 103 distributed (response rate 43%). Eighty percent of the respondents indicated that the RTCS enhanced their sense of professionalism.
Conclusions: Our findings suggest that use of RTCS is associated with enhanced RT retention and a high level of career and job satisfaction. While recognizing that factors other than the RTCS may have contributed to these outcomes, we believe that the salutary effects of a RTCS on the "culture" of our section along with the institutional benefits of increased respect for therapists' professionalism and enhanced scope of practice establish the RTCS as a strong contributor to increased RT retention and career satisfaction.

OF-01-177

Evaluation of Vacuum Outlet Performance

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Background: Hospital vacuum system performance is dependent on the function of a duplex of two or more vacuum pumps which alternately or simultaneously supply vacuum on demand. Functional maintenance of vacuum systems is focused toward maintaining vacuum pressure via vacuum pump maintenance and repairing leaks. The performance of individual vacuum outlets, in regards to suction effectiveness, is dependent on the flow rate through the outlet at any given vacuum pressure. Flow rate through a suction outlet is limited by the resistance across the outlet valve. Following observations of inefficient vacuum outlet performance in the intensive care unit with closed tracheal suction catheter use, vacuum outlet flow rates were measured to determine the extent of the problem.

Methods: A threaded vacuum outlet nut with a 1/4 inch barbed nipple was attached via a one foot length of suction tubing to the outlet end of a Boehringer handheld spirometer using a 22 mm OD, 15 mm ID adapter and a 5.0 mm endotracheal tube connector. The vacuum outlet nut was attached directly to the vacuum outlet on the wall panel until the outlet check valve was fully opened. The volume of air in liters aspirated through the vacuum outlet was measured on the Boehringer spirometer for 15 - 30 seconds. The flow rate through the outlet was calculated in liters per minute. The measurement was repeated three times for each outlet and the results were averaged. A total of 52 vacuum outlets in 18 intensive care unit rooms were assessed. The results were reported to hospital engineering. The measurements were repeated four months later following cleaning and replacement of component parts in the vacuum outlet check valves.

Results: The median and mean ± standard deviation of vacuum outlet flow rates pre and post maintenance were 48 and 47 ± 21 L/min, and 86 and 82 ± 14 L/min respectively. Vacuum outlet flow rate markedly improved following maintenance in all but one outlet. Vacuum outlet flow rates of ≥ 60 L/min were determined to be functionally adequate. The initial measurements revealed that prior to maintenance 63% of the vacuum outlets performed below this threshold vs 6% following cleaning and replacement of parts.

Conclusions: Based on our experience we recommend that preventative maintenance of vacuum outlets occur on a regular basis with specific focus on maintaining functionally adequate flow rates (≥ 60 L/min). Preventative maintenance should include cleaning and or replacement of component parts. Maintenance of adequate vacuum outlet flow rates may also impact the user perception of the effectiveness of closed tracheal suction catheters.

OF-01-184

OUTCOME ASSESSMENT OF AN INSTITUTION'S MISSION: COMMUNITY SERVICE AND STUDENTS' PERCEPTIONS OF CARING FACULTY

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Background: Respiratory care education programs are required to provide outcome data and assessment on student performance. There is more than just grades and class standing that reflect the total education sought by institutions of higher education. This study sought to discover students' perspectives of a health science institution's mission. A set of models for understanding the institutions mission were developed by comparing the relationships between students' expectations and the universities documents and statements.

Methods: A qualitative inductive grounded theory design was used so that themes could emerge. Relevant informants were: students (via interviews and focus group); institutional documents; and institutional publications. Fourteen senior occupational therapy students were selected from the institutions School of Allied Health Professions (Loma Linda University, LLU). A combination of triangulation and constant comparisons was employed in the analysis of this study. Students' expectations, students' perceptions, and the university's expectations (i.e., goals for the ideal graduate), as reflected in its mission statement, were compared.

Results: Six main categories (themes) emerged from students' perceptions of their experiences related to institutional mission. In addition, sixteen subcategories (subthemes) emerged, which helped to clarify the main themes. The main categories were: (1) expectations of a specific worldview; secular or sectarian, (2) reasons for selecting the institution; (3) institution-wide programs and activities; (4) diversity; (5) the occupational therapy professional program; and, (6) LLU's promotion of its mission.

Conclusions: Analysis and data comparison revealed that students expressed that their experiences with/of both a caring faculty and community service furthered the institution's mission. Students perceived the institution's mission as relevant when their expectations of worldview and the institution's expectations were congruent. Students' expectations were actualized through caring faculty and community service. Students' reports lead to the development of an inventory of: (1) their concept of caring faculty (perceived as positive); (2) their concept of non-caring faculty (perceived as negative); (3) actual behaviors associated with caring faculty; and, (4) actual behaviors associated with non-caring faculty. Finally, a conceptual model was developed to assist the university in realizing it's mission. Congruence occurs when students experience caring faculty and community service. Caring faculty and community service could enhance conveying a respiratory care's program mission.

OF-01-192

Cost Reduction Following Conversion to Masimo SET Pulse Oximetry – Experience in the Neonatal ICU

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Introduction – Recent publications have focused on pulse oximetry technology, specifically changes in artifact rejection, low perfusion sensitivity and alarm management. However, little information has been presented concerning the financial implications of utilizing this new technology. Additionally, Masimo Corporation (Irvine, CA.) has introduced innovations in sensor design and technology that claim to increase the durability and longevity for sensors. We evaluated these changes in sensor performance and the cost associated with using Masimo oximetry in our 39 bed level III Neonatal ICU (NICU).

Methods – All patients admitted to the NICU are monitored with pulse oximetry for the duration of their admission. Criticare 504US oximeters with 573SD sensors had been used in our NICU prior to October 1, 2000. At that time we began a conversion to Masimo SET oximetry, using the Radical oximeter and NeoPt sensors throughout our NICU. We evaluated the number of sensors utilized per patient admission for a three month period of time (post) and compared this to the same three month period of time prior to the conversion (pre). We determined the number of sensors consumed in the NICU and the number of admissions, length of stay (LOS) and average daily census for the two time periods. Additionally, we surveyed the staff (RNs, RRTs, and MDs) to determine their impression of the Masimo sensors.

Results – NICU census and sensor utilization data are summarized in the table below.

	# of Admissions	Daily Census	# of Sensors Consumed	Sensors per Admission	Sensor Longevity (days)
Criticare sensor	213	32.7	544	2.6	4.8
Masimo sensor	265	38.1	400	1.5	11.5

Average LOS was calculated, "pre" = 12.6 days, "post" = 17.2 days. It was noted that during the "post" time there was an increase in the number of patients receiving ECMO in the unit, increasing length of stay. Average sensor longevity was calculated as LOS / sensors per admission: Criticare = 4.8 days, Masimo = 11.5 days. When asked to determine the durability and useful life of the Masimo sensor, 83% of the staff rated Masimo superior to the previous sensor. 78% of the staff rated Masimo superior in the ease of acquiring initial oximetry readings. 96% of the staff reported that changing to Masimo sensors has resulted in less handling of infants to "fix or adjust" sensors in order to obtain reliable saturation values.

Conclusions – Conversion to Masimo oximetry has resulted in a 58% reduction in sensor consumption in our NICU. Masimo sensors lasted 11.5 days, on average, which is approximately 2.4 times as long as the Criticare sensor. In our experience Masimo oximetry sensors significantly reduce the cost of oximetry monitoring. We attribute this to their increased durability and ease of acquiring initial oximetry readings.

OF-01-223

AN INVESTIGATION IN LEADERSHIP STYLES AND EMPLOYEE OUTCOMES IN RESPIRATORY CARE- Anna W. Parkman, Ph.D., MBA, RRT, University of Charleston, Charleston, WV.

BACKGROUND: Respiratory care managers and supervisors are challenged as never before to deliver cost effective quality care in an era of decreasing compensation, alarming manpower shortages, and rising consumer expectations. In an effort to meet the continually changing demands of the health care systems and provide leadership within the profession, many have begun to explore leadership styles and the effects these have on employee outcomes particularly those related to retention and productivity. No published studies focus on leadership styles and outcomes in Respiratory Care. METHODS: A nationwide random sample (N=841) of staff respiratory therapists completed Bass's Multi-Factor Leadership Questionnaire (MLQ 5X-Short Form) to determine the relationship between the transformational, transactional, or the laissez-faire leadership style of respiratory care managers and the outcome variables of satisfaction with the leader, perception of leadership effectiveness and willingness to exert extra effort. The data was analyzed utilizing the multivariate analysis techniques of product-moment correlation coefficients and multiple regression to examine the relationship between independent and dependent variables. Correlation coefficients were utilized to assess the strength of the linear relationship between demographic variables, the MLQ Form derived leadership factors, and the outcome variables. RESULTS: Staff therapists working in the acute care environment perceive the supervisors and managers to whom they report as exhibiting transformational leadership behaviors more frequently than transactional or laissez-faire leadership practices. A significant relationship (p=0.01) exists between the respiratory care manager's leadership style as perceived by the employee and all three of the outcome variables. Further, findings indicate that there is no significant relationship between gender and the leadership style of respiratory care managers and supervisors as perceived by subordinate staff therapists. CONCLUSION: Bass's (1985) Full Range Model of Leadership offers leaders in the field the opportunity to directly impact on outcomes in the respiratory care department. The findings indicate an opportunity to increase positive subordinate outcomes and retention of employees through the application of transformational leadership in respiratory care.

OF-01-264

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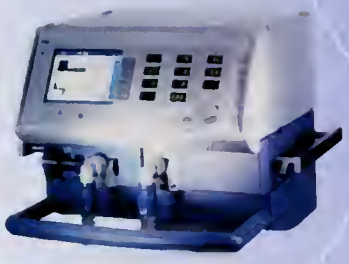

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EARLY HIGH FREQUENCY OSCILLATORY VENTILATION (HFOV) vs SYNCHRONIZED INTERMITTENT MANDATORY VENTILATION (SIMV) FOR VERY LOW BIRTH WEIGHT (VLBW) INFANTS

Jeanette M. Asselin, David J. Durand (Children's Hospital Oakland, Oakland, CA), Sherry E. Courtney (Cooper Hospital, Camden, New Jersey), and The Neonatal Ventilation Study Group.

Background: Clinical trials comparing high frequency ventilation (HFV) to conventional ventilation have yielded conflicting results about whether HFV improves pulmonary outcome in VLBW infants. Whether HFV increases severe intraventricular hemorrhage (IVH) and/or cystic periventricular leukomalacia (PVL) is also uncertain.

Objective: To determine whether early institution of HFOV, compared to SIMV with continuous tidal volume monitoring, improved the pulmonary outcome of VLBW infants without increasing the incidence of IVH and/or PVL.

Design/Methods: 500 infants from 26 centers were enrolled into a prospective randomized trial. Eligible infants were 601-1200 g birthweight and ventilator-dependent after one dose of Survanta. Infants were randomized and placed on their assigned ventilator as soon as possible after birth. Patients were treated with ventilator strategies which included permissive hypercapnea, monitoring of lung inflation and tidal volume, aggressive weaning, and standardized extubation criteria. All infants received prophylactic indomethacin. Neuroultrasounds were done at specified times and interpreted by a single masked reviewer.

Results: 482 patients completed the study.

	HFOV	SIMV	P
N	232	250	
Birth weight (gms)	861 ± 161	849 ± 160	0.42
Age randomization (hrs)	2.7 ± 0.9	2.7 ± 0.9	0.72
Postnatal steroid Rx (days)	9.5 ± 12.4	12.3 ± 14.1	0.018
Age extubation prim disease (days)	17.3 ± 16.6	24.2 ± 19.2	0.0002
Alive w/o chronic lung dis at 36 wk	131	117	0.036

Neuroultrasound results indicate no difference in severe IVH and/or PVL.
Conclusions: Early use of HFOV improves pulmonary outcome of VLBW infants, even when compared to a strategy of tidal ventilation which includes synchronization and targeting tidal volume. HFOV does not increase the incidence of severe IVH or cystic PVL.

Disclosure: Funded in part by the Society for Pediatric Research Multicenter Trials Program, Abbott Laboratories/Ross Products Division, SensorMedics Corp., EME Ltd., Ballard Medical, and Natus Medical Products. OF-01-020

A PROSPECTIVE RANDOMIZED COMPARISON OF THE VOLUME DIFFUSIVE RESPIRATOR® (VDR) VS. CONVENTIONAL VENTILATION FOR TREATMENT OF BURNED CHILDREN

Brad Carman, RRT, Thomas Cahill, RRT, Glenn Warden, MD, John McCall, MD
Shriners Hospital for Children, Cincinnati Burns Hospital

Introduction: The Volume Diffusive Respirator® (VDR) (Percussionaire, Sandpoint, ID) is a high frequency time cycled pressure ventilator that can ventilate, oxygenate, and promote secretion removal. The VDR produces lower airway pressures compared to conventional ventilation in the pressure control mode (CV). The VDR has been reported to be advantageous in retrospective studies. A prospective, IRB approved study was conducted comparing the VDR to CV in burned children to assess outcomes such as ventilator settings, ventilator days, pneumonia, and barotrauma. **Methods:** Pediatric burn patients requiring ventilation were stratified by presence of inhalation injury and ventilated by VDR or CV to achieve predefined arterial blood gases. The data recorded included age, cause of burn, total body surface area burned (%TBSA), best P/F ratio, number of ventilator days (vent days), maximal peak inspiratory pressure (PIP)/amplitude, incidence of barotrauma, pneumonia, respiratory distress syndrome (RDS), sepsis, and survival. **Results:** Sixty-four patients were prospectively assigned ventilator type; 32 to VDR, 32 to CV. Data reported as mean ± SEM. Patient age was 7.4±0.7 yrs, TBSA was 56±3%, and number of inhalation injuries was 55 (86%). Multiple logistic regression analysis revealed the maximum PIP (cm H_2O) with the VDR was significantly less than with CV (30.9±0.8 vs. 39.5±1.8 $p<0.05$) and the best P/F ratio was significantly higher with the VDR compared to CV (563±15 vs. 507±13 $p<0.05$). No patient in the VDR group had evidence of barotrauma compared to two in the CV group. Five patients in the CV group expired compared to two in the VDR group. **Conclusion:** Patients ventilated with the VDR required significantly lower PIP than with PCV. Patients achieve a significantly higher P/F ratio on the VDR when compared to conventional pressure control ventilation. This demonstrates the VDR is a safe and effective method of ventilation for pediatric burn patients and it offers advantages when compared to conventional ventilation.

OF-01-051

ONE-YEAR EXPERIENCE WITH NITRIC OXIDE FOR INTERHOSPITAL TRANSPORT DURING NEONATAL MECHANICAL VENTILATION

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INTRODUCTION Newborns with respiratory failure complicated by persistent pulmonary hypertension (PPHN) of the neonate are frequently transported to our hospital for continued medical management and possible ECMO. We previously described [Respir Care 1998;43(10):832] a portable nitric oxide delivery system (PrinterNox, Micromedical) for use with our transport ventilator (Biomed MVP-10) to provide inhaled nitric oxide (iNO) to ventilated neonates during interhospital transport. We describe one year's experience with this system. **METHODS** Term and near term infants (>34 weeks gestation) with respiratory failure were identified at the time of referral. Patients <34 weeks gestation were not enrolled. The transport team consisted of a respiratory therapist, a physician (attending or fellow), and a nurse. Consent was obtained for iNO if the oxygen index (OI = mean airway pressure x FIO_2 x 100 / PaO_2) was greater than 40 after optimized medical & ventilator management at the referral center. Patients with an OI = 40, who were medically stable, were transported without iNO. Patients who had an OI = 40, who were not medically stable, were eligible to receive iNO at the discretion of the transport attending neonatologist. Patients were then followed in the NICU for outcome and adverse side effects of iNO therapy. **RESULTS** In year 2000, 7% (21/296) of transported infants with respiratory failure were identified as potential candidates for iNO during interhospital transport (mean OI = 40.1 median =36). 90% (19/21) had a diagnosis of primary PPHN or pulmonary hypertension associated with identified lung disease such as meconium aspiration syndrome or pulmonary hypoplasia. 38% (8/21) qualified for iNO during transport (mean OI = 58.5). Seven of 8 responded to iNO. The mean saturation increased from 65% to 92% (mean increase in sat. = 27%, median 30%). Two of 8 eventually went on ECMO (mean OI = 67). An additional 8 who did not qualify for transport iNO eventually qualified for iNO treatment (mean OI = 31, median OI = 34). Five of 21 (23.8%) were managed with medical and ventilatory management alone (mean OI = 26.2). There were no mechanical problems reported with the transport delivery system. There were no adverse effects reported from the use of NO in these patients. Six of 21 patients (29%) later expired or had support withdrawn (mean OI = 42.7). Two had birth asphyxia, one had Vein of Galen malformation, one had homozygous achrondroplasia and two had pulmonary hypoplasia. Two of the 6 had received iNO on transport (mean OI = 71). No patient expired during transport or during the first 72 hours following transport. **CONCLUSIONS** Selective use of iNO to improve oxygenation in the sickest neonates with respiratory failure (OI>40) enhances respiratory stability during transport and may save lives. This series provides compelling evidence that iNO has a place in the neonatal transport armamentarium.

OF-01-066

NON-INVASIVE POSITIVE PRESSURE VENTILATION OF A PEDIATRIC PATIENT WITH SPINAL MUSCLE ATROPHY: A CASE SUMMARY

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Introduction: Non-invasive positive pressure ventilation (NPPV) is one of the tools that we use to treat dyspnea and improve the quality of life of the patient with terminal disease[1]. Its use, however, has limitations and adverse effects. NPPV's associated adverse effects include nasal congestion, nasal/oral dryness, nasal redness, nasal ulceration, mask discomfort/leakage, gastric distension, eye irritation, aspiration, inability to ventilate, failure to tolerate, and skin breakdown. The following case summary will focus on the challenges of maintaining skin integrity of a pediatric patient managed with NPPV. **Case Summary:** This is a 5-month old with reactive airway disease and gastric esophageal reflux who was diagnosed at 1 month of age with Spinal Muscle Atrophy (SMA) Type 1. SMA Type 1 is an autosomal recessive disease; the most common inherited neuromuscular disease of the hypotonic newborn[2]. During a scheduled, outpatient diagnostic barium swallow, the patient suffered a cyanotic event. Subsequent interventions included oxygen, intubation and positive pressure ventilation. She was transferred to the Pediatric Intensive Care Unit for management of presumed aspiration pneumonia. The transition to NPPV immediately post extubation, enabled us to wean from invasive positive pressure after a period of 8 days. The goal was to support the child non-invasively while she continued to recover from this acute episode. It soon became evident that her chronic illness had progressed such that a full recovery to her previous baseline would not occur. Ongoing complications of NPPV were addressed regularly in this patient who now required continuous NPPV. The goals of the therapy were successfully met, but not without the serious adverse effect of skin breakdown. Over the next 6 weeks, trials of NPPV and multiple mask type interfaces proved to be unsuccessful, as the child's skin breakdown worsened. Plastic surgery was consulted and nasal bridge wound management was more specifically addressed, meanwhile, the search for alternatives continued. A nasal prong interface was attempted. This alternative method of delivery was well tolerated by the patient and allowed for the healing of her wound. Eventually this patient was successfully transitioned to home on continuous NPPV utilizing a combination interface of nasal mask and nasal prongs. **Discussion:** Maintaining skin integrity is one of the biggest challenges to the implementation of non-invasive positive pressure ventilation, particularly in patients with neuromuscular disease who are high risk for complications related to limited mobility. Pressures sores created by the nasal mask fit many times lead to staged wounds requiring surgical intervention. Nasal prongs, used as an alternative NPPV system interface, seemed beneficial in the care of this 5-month-old infant with SMA Type I. More avenues need to be explored regarding the limited availability of equipment to interface small children with NPPV.

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2. Bach JR, Niranjan V., and Weaver B. Spinal Muscle Atrophy Type 1* A Noninvasive Respiratory Management Approach. Chest 2000; 117: 1100-1105.

OF-01-080

Evaluation of Complications Caused by Conventional and Fluidic Nasal CPAP in the NICU: An Observational Study

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Introduction: Nasal CPAP is used in neonates with Respiratory Distress Syndrome to increase functional residual capacity, decrease airway resistance, improve oxygenation and improve pulmonary compliance by the mechanism of alveolar stabilization. (*Pediatrics* 2001, 107 2 304-308) Accompanying the physiologic benefits of delivering nasal CPAP are potential risks of complications. We have observed a number of complications in patients receiving conventional and fluidic nasal CPAP in the Neonatal Intensive Care Unit (NICU) at our institution. The purpose of this study is to compare the incidence of complications associated with two types of nasal CPAP and to isolate the factors leading to them. **Methods**: From November 1, 2000 to May 1, 2001, 111 patients were placed on nasal CPAP in our NICU. Our NICU primarily utilizes two types of nasal CPAP: Conventional and fluidic nasal CPAP. The conventional nasal CPAP was delivered with CPAP prongs (Medicomp Inc. Princeton MN) on the Infant Star ventilator, and the fluidic nasal CPAP was delivered by the Arabella CPAP system (Hamilton Medical, Reno NV) utilizing their universal generator set and circuit. Conventional nasal CPAP sets were secured with Arabella CPAP caps and twill tape. Fluidic nasal prongs and generator sets were secured with the Arabella CPAP caps. The following demographic data were collected: gestational age, weight, type of CPAP, nasal prong and hat size, use of a protective duoderm strip under the nares, circuit temperature, and start/stop dates and start/stop times. Patients were assessed daily by two observers for complications including: nasal septal breakdown, flaring or stubbing of the nares, bleeding, and orbital edema. Subsequent CPAP episodes of previously enrolled patients were excluded from this study. The NICU staff was blinded to this observation. Data were analyzed using a multivariate logistic regression to determine causative factors for complications. **Results**: In this observational study, 20 % of all patients placed on nasal CPAP developed complications. 20 % of infants placed on continuous flow nasal CPAP developed complications, while 20 % of patients placed on variable flow nasal CPAP developed complications. Complications and their p-values are listed in the table below

		95% Confidence Interval		
Complication	Odds Ratio	Lower	Upper	P-value
CPAP Type: Fluidic	3.73	1.000	13.927	0.05
Temperature	1.51	0.831	2.738	0.18
Hat Size	0.98	0.385	2.499	0.97
Duoderm	1.67	0.616	4.504	0.31
Duration	1.38	1.092	1.746	0.007
Gestational Age	0.96	0.776	1.178	0.67
Birth Weight	1.00	0.999	1.001	0.83

Conclusions: Only CPAP type and duration of nasal CPAP had significant effects on complication rate. Fluidic CPAP was 3.7 times more likely to result in complications than conventional CPAP. A one-day increase in nasal CPAP duration was associated with a 38% increase in the risk of complications.

OF-01-138

EVALUATION OF MANUAL VENTILATION USING THE NEOPUFF INFANT RESUSCITATOR DURING TRANSPORT OF THE PREMATURE INFANT

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Introduction: Manual ventilation is a daily task performed in the Neonatal Intensive Care Unit (NICU) during suctioning, resuscitation and transport. The Neopuff Infant Resuscitator (Fisher & Paykel Inc.) is manually triggered, pressure limited and manually cycled and is pneumatically powered by a flowmeter. One potential use for this device is to transport preterm infants requiring mechanical ventilation. A previous study by Keenan et al (*Resp Care* 1999, 44 (10), 1252) demonstrated variability of tidal volumes (Vt) and PEEP's with a pediatric-aged, simulation of anesthesia bag ventilation. This study was designed to compare the accuracy and consistency of manual ventilation in achieving a set of predefined ventilatory parameters using the Neopuff resuscitator versus conventional anesthesia bag ventilation during simulated patient transport. **Methods:** An incubator (Airshields Isolette) was equipped to simulate a typical NICU transport with an Infant Star test lung serving as a patient. Nineteen staff therapists were asked to ventilate the test lung at predefined target parameters: peak inspiratory pressure (PIP) of 22 cmH$_2$0, PEEP 5 cmH$_2$0, respiratory rate (RR) of 30 breath/minute (bpm), and 100% FiO$_2$ using an anesthesia bag and the Neopuff Resuscitator. For anesthesia bag ventilation, a pressure monitor was available for use at the therapist's discretion. The simulated patient's ventilatory parameters were monitored by two hand held pulmonary mechanics monitors: Novametrix Vent Check (Novametrix Medical Systems Inc.) and the Breath Tracker 1705 (Core-M Precision Instruments Inc.), which also measured the delivered tidal volume (Vt). The length of the simulated transport was approximately 125 feet. Data were recorded as the highest and lowest measured values for each parameter during the transport. The consistency of the data for each parameter was estimated by the range (highest value minus lowest value). Accuracy in achieving and maintaining ventilatory parameters was evaluated as error (error = mean measured value – target value). The mean value for each parameter was estimated as the range divided by 2. Unpaired t-tests were used to compare mean values for consistency and error between anesthesia bag versus Neopuff (significance at p< 0.05) manual ventilation. **Results**: The data below summarize the performance of all 19 therapists as mean ± SD:

	Error			Consistency		
	Bag & Mask	Neopuff	p	Bag & Mask	Neopuff	p
PIP (cmH20)	2.2± 2.4	1.7 ± 1.6	0.32	24.2 ± 2.4	23.7 ± 1.5	0.40
PEEP (cmH20)	0.4 ± 0.9	0.3 ± 0.8	0.01	4.6 ± 0.9	5.3 ± 0.8	0.01
RR (bpm)	7.6 ± 10.4	1.5 ± 9.8	0.07	37.6 ± 10.4	31.5 ± 9.8	0.07
Vt (mL)	N/A	N/A	N/A	23.1 ± 3.8	20.9 ± 2.2	0.05

Conclusion: In this simulation of transport ventilation, the Neopuff Infant resuscitator provided more accurate and consistent Vt and levels of PEEP. Study participants viewed the Neopuff resuscitator as an easier and more consistent method of manually ventilating infants during transport because it required less manipulation of the endotracheal tube while consistent pressures were maintained.

OF-01-150

CLINICAL EXPERIENCE WITH THE VIP GOLD VENTILATOR IN THE PEDIATRIC INTENSIVE CARE UNIT Katie Sabato MS RRT, Vivienne Newman M.D. Childrens Hospital Oakland CA.

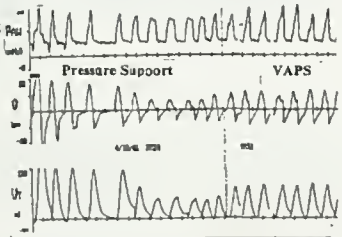
BACKGROUND: The VIP GOLD ventilator, released Dec 1999, has several advanced functions and modes including 1) flow triggering at the airway, 2) a clinician set back up time limit for pressure support (PSTL), and 3) Volume Assured Pressure Support (VAPS). Currently, there is no published data describing clinical results with these modes. We describe the following 5 case reports that highlight our initial experience.

DISCUSSION: Patient 1, weighing 2.8kg and patient 2, weighing 8kg, were hospitalized with RSV, and initially ventilated with a pressure control/volume assured mode. They both experienced difficulty weaning and inability to trigger and cycle their spontaneous breaths. This phenomenon of failure to trigger and cycle was previously published (1). Clinically, these patients exhibited tachypnea, retractions and an increase in oxygen requirement. When switched to the VIP Gold, using PSTL function, and flow trigger at the airway these problems were eliminated, and the patients exhibited improvements in ventilation and proceeded to extubation in a more timely fashion, as shown below.

Case	Initial Blood Gas	Blood Gas on GOLD	Time to Extubation
1	7.29/50 on 60%	7.42/38 on 40%	12 hours
2	7.26/54 on 55%	7.35/44 on 40%	24 hours

Case 3, a 4-kg suffered from severe BPD. Case 4, a 6-kg cardiothoracic surgery patient, required weeks of paralysis following surgery and had 2 unsuccessful attempts at extubation. Case 5, a 15-kg had status epilepticus and aspiration pneumonia. These 3 patients exhibited rapidly changing patient flow demands associated with periods of inadequate tidal volume delivery while ventilating in Pressure Control mode. The VIP GOLD VAPS mode assures a minimal tidal volume using pressure support, with a demand variable flow. Once placed into VAPS, and without any other change in medical intervention, patient flow demands were matched and periods of hypoventilation with associated ateletasis were avoided. Weaning and extubation were successful in each case.

Adjoining figure illustrates improved tidal volume delivery when switching from Pressure Support to VAPS.



SUMMARY: Our experience with the VIP GOLD ventilator suggests improved patient synchrony and comfort, and a potential decrease in duration of mechanical ventilation in the critically ill pediatric patient.

(1) *Sottiaux. Respiratory Care March 2001: pgs 255-233.*

OF-01-176

NASOPHARYNGEAL PRONGS FOR INFANTS LESS THAN 2 KILOGRAMS, A DEVICE EVALUATION

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Background: Binasal Nasopharyngeal (NP) prongs are often used for the delivery of nasal continuous positive airway pressure (NCPAP). These types of prongs are inserted through the nares and nasal cavity and past the choana into the nasopharynx. An alternative method of providing NCPAP is with the use of nasal prongs, which are secured in the nares only. NP prongs offer some advantage over the nasal prongs in that the longer length allows the nasal anatomy to assist in the security of placement. Previously, NP prongs were only available in lengths of 4 cm and 9 cm. When inserted at full length, these prongs would clearly be too long for small infants, and would pass the desired placement in the nasopharynx and deliver positive pressure to the esophagus. Attempts to secure these prongs at a length appropriate for infant size resulted in cutting the prongs or leaving a section of the prongs outside the nares. Recently, NP prongs have been developed specifically for use in premature infants (Neotech Products, Inc), providing varying lengths at the same unit cost as standard NP prongs. By providing a more appropriate length for infant size, these prongs have less dead space to obstruct CPAP flow. The purpose of this report is to detail recent experience with the new "premie NP prongs."

Methods: Over a 4-month period, infants <2 kg were extubated to the standard 4 cm NP prongs used in our nursery. Those infants perceived as having clinical problems on NCPAP were switched to the "premie NP prongs", length 2.5 cm, diameter 2.5-3.0 mm depending on size of infant. Data were collected retrospectively concerning number of apneas, carbon dioxide level, and feeding tolerance before and after the change in binasal prongs. During the 4-month period, questionnaires were distributed to nursing and respiratory therapy personnel to assess comfort and satisfaction with the two types of binasal prongs, using a 1-10 rating scale.

Results: During this 4-month period, 12 infants (weight 0.700-1.5 kg) were switched to the "premie NP prongs" due to perceived less than optimal clinical status using the standard NP prongs. Four of the 12 infants had previously failed an attempt of extubation using the standard NP prongs. Within 24 hours, all 4 infants were successfully extubated using the "premie NP prongs." Of the remaining 8 patients, there was a trend for less apneic episodes, lower carbon dioxide level, and better feeding tolerance on the "premie NP prongs." Caregiver satisfaction was significantly higher in the 5 areas assessed: irritation (p<0.001), stability (p=0.05), patency (p<0.007), positioning (p<0.001), and comfort level (p=0.001). Under the comments section of the questionnaire, 12 of the 40 caregivers surveyed independently made statements concerning improved air movement and breath sounds on auscultation when using the "premie NP prongs" compared to the standard NP prongs.

Conclusion: Nursing and respiratory caregiver comfort level in caring for infants on NCPAP was improved with the "premie NP prongs." In comparison to standard 4 cm NP prongs, "premie NP prongs" were easier to position, were less irritating to the nose, and more easily secured. Moreover, 33% of the infants supported by NCPAP using the standard NP prongs failed extubation, but went on to be successfully extubated when using the "premie NP prongs." All infants appeared clinically improved with properly positioned NP prongs. Proper sized prongs appear to improve clinical respiratory condition and result in less NCPAP failure than standard length prongs. The unit cost of the "premie NP prongs" is the same as that of standard NP prongs, but it seems they are easier to use and provide improved support.

OF-01-207

FACTORS ASSOCIATED WITH MECHANICAL VENTILATION IN A PEDIATRIC POPULATION. Ronald E. Dechert, RRT, Roxanne Sadowski, RRT, Colleen Ducker, RRT, Jennifer Benson, RRT, Sue Smith, RRT, Sue Mack, Kenneth Bandy, RRT, Frank Moler, MD, Joseph Custer, MD. University of Michigan Medical Center, Ann Arbor, Michigan

Introduction: Mechanical ventilation (MV) is commonly employed in support of pediatric ICU (PICU) patients who exhibit respiratory dysfunction. Many RC departments employ protocols to reduce the incidence or duration of MV in this population. Scant empirical information exist which identify various baseline factors that are associated with MV in this population. As a result, few protocols account for contributory factors in the development of treatment protocols. The purpose of this study is to examine factors associated with pediatric MV. **Methods:** 1979 PICU admissions were included in this retrospective, case-control study. Co-morbidities such as age, prior ICU admission, operative status, and diagnosis, as well as, worst perturbed physiologic parameter during first 24 hours following admission were captured for each of the 1979 patients. Cases were identified as those patients who required MV at anytime during their PICU admission. Once patients were appropriately identified (case/control), the comorbities and physiologic derangements were examined using bivariate analysis to identify those factors that were associated with the need for MV. **Results:** The result are shown in table 1 below:

Parameter	Cases (n=754)	Controls (n=1225)	p-value
Age	5.4 ± 5.8	6.9 ± 6.1	<0.001
BP systolic (highest)	118 ± 23	122 ± 19	<0.001
Heart Rate (highest)	153 ± 29	142 ± 29	<0.001
pH (highest)	7.42 ± 0.09	7.37 ± 0.16	<0.001
Previous ICU	162/754 (27%)	115/1225 (9%)	<0.001
Cardiac arrest	16/754 (2%)	11/1225 (1%)	0.023
Cardiac arrythmias	109/754 (14%)	91/1225 (7%)	<0.001
Meningitis	29/754 (4%)	22/1225 (2%)	0.005
Pneumonia	163/754 (22%)	104/1225 (8%)	<0.001
Sepsis	331/754 (44%)	377/1225 (31%)	<0.001

Conclusions: Our study demonstrates that a variety of factors, present or immediately following PICU admission, are associated with the need for MV in our pediatric population. The importance of these and other factors in predicting the need for or duration of MV in a PICU population must be further delineated. Identification of contributory factors associated with MV, as identified in this study, may further aid practitioners in the development of treatment protocols that target MV support and duration.

OF-01-211

SUCCESSFUL USE OF HIGH FREQUENCY VENTILATION PROTOCOL IN A PEDIATRIC INTENSIVE CARE UNIT: A CASE REPORT. Brenda k. Batts M.P.H.,RRT, Hughes Spalding Children's Hospital, James McCrory, M.D. Pediatric Critical Care, Morehouse School of Medicine, Hughes Spalding Children's Hospital, Jean Johnson, B S ,RRT, Respiratory Clinical Specialist,SensorMedics

Introduction: The 3100A High Frequency Oscillator was introduced in 1991 for rescue and early intervention applications in neonatal patients. The benefits of both early intervention and rescue applications of high frequency ventilation have been supported in several multi-center randomized control trials and numerous peer reviewed articles and abstracts. The 3100A has been shown to be effective in the treatment of newborns with respiratory distress syndrome, airleak and airleak syndromes, meconium aspiration, pneumonia, persistent pulmonary hypertension of the newborn and congenital diaphragmatic hernia. Additional benefits include reduced incidences of chronic lung disease, reduced exposure to high oxygen concentrations, and a reduction in days of mechanical ventilation. In 1995, the 3100A was approved by the F.D.A. for use on children with severe respiratory failure who, were failing conventional mechanical ventilation. Failing on conventional ventilation is defined as an oxygen index greater than 13 in two ABG's during a six hour period. We report the use of HFOV protocols which included assessing the oxygen index as an indicator to determine intervention time. Case Summary: The patient was an 11 day old male born at 36weeks gestation. Mom required induced labor secondary to preeclampsia. NSVD. BW4lbs, 14oz. Hospital stay 4 days secondary to hypothermia, hypoglycemia, hyperbilirubinemia. Mom reported patient had a 24hour history of panting, and grunting while sleeping, with occasional episodes of slow breathing. While enroute to the emergency center, mom noted blood coming out of mouth, and then patient stopped breathing. She gave rescue breaths, and called 911. Patient responded, but required constant stimulation to breath. Patient arrived at the emergency center on 3lpm of oxygen in respiratory distress with pulse ox saturations 91%, HR 137, RR49, temperature 35.5 rectal. Patient placed on CPAP via ambu bag with 100%FiO2 sats increased to 94%. Patient stopped breathing code called, patient intubated ,and transfered to the Pediatric Intensive Care Unit. Initially patient was set up on Servo 300 ventilator in SIMV/PC/PS Mode, rate 40,. 20/10, 100FiO2, saturations 100% with Paw=11. Day two patient had sudden deterioration to 80% saturations, required bagging with pressures of 36/10 to increase sats to low 90's. A CXR revealed total white outof all lung fields. The team elected to place the patient on high frequency ventilation. The patient was placed on HFOV using the SensorMedics 3100A. Intial settings were Paw=30, Delta P=45, Ti=33%, Fio2=100%, and bias flow=20lpm. Unable to obtain artline ,venous samples revealed hypoxemia with 20-30 Pao2's and saturations 93-97%. 12hours later artline obtained, inital oxygen index=40 with a repeat six hours later = 58. After 36 hours of HFOV at maximum settings, patient developed acute renal failure complicated with his ARDS, and gram negative sepsis. Patient was successfully transponed to an ECHMO center for a trial of ECHMO. CONCLUSION: The use of a high frequency ventilation protocol, helped us to identify early that this patient was not responding to the HFOV, and that the underlying etiology may have been cardiac, and not respiratory. Upon arrival to the ECHMO center an echo revealed a PDA, which was successfully surgically ligated.

PICU-HFOV VENTILATION PROTOCOL
INITIAL MANAGEMENT

Intubated and conventionally ventilated patient with an OI of 13 or> for 2 ABG's 6hrs apart
Mean Airway Pressure (MAP) 4-8cms>than MAP of CMV
Frequency according to body size 2-12kilo's =10Hz, 13-20kilo's=8Hz, 21-34kilo's=7Hz, 35kilo's or >=6Hz
Power Setting at 4.0-Achieve a Chest Wiggle(CF), a visual chest vibration from shoulders to groin
Fi02 at 100%, Inspiratory Time%at 33%, Bias Flow at 20LPM or greater
Assessment: Pulse oximeter to be maintained between 90-93%
Trancutaneous CO2 Monitor to stabilize between 50-60 Torr or appropriate Paco2
Check ABG/CBG at 1Hr to correlate TC CO2, and observe pH. Ph < 7.25 Consult Physician
CXR to be obtained at the 1st hour of stabalization- 9 rib level or better with decreasing opacification
Hemodynamics stable with Mean Arterial Pressure greater than 60mmhg

OF-01-226

Airway Pressure Release Ventilation (APRV) in an Infant with Chronic Lung Disease: A Case Summary. Angela S. Mittman BS, RRT, P/P Spec., Theresa Ryan Schultz BA, RRT, RN, Lynne Crook AS, RRT, P/P Spec., Istvan Seri MD, PhD. The Children's Hospital of Philadelphia, Philadelphia PA

Background: Airway Pressure Release Ventilation (APRV) uses two different levels of inflating pressure while enabling unrestricted breathing during both the inspiratory and the expiratory phase of the mechanical breathing cycle. Previous studies in children and adults have found that APRV provides adequate ventilation and oxygenation at lower peak inflating pressures (PAP) than produced by Synchronized Intermittent Mandatory Ventilation (SIMV), and may significantly reduce the need for relaxants and sedatives.[1,2] However, no reports are available on the use of APRV in neonates and young infants. Management of infants with Chronic Lung Disease (CLD) and advancing postnatal age demands a constant balance between ventilatory and sedation needs. **Case Summary:** This is a former term infant with a history of left Congential Diaphragmatic Hernia (CDH), associated pulmonary hypoplasia and chronic ventilation perfusion (VQ) mismatch, as well as bronchomalacia, gastroesophageal reflux and CLD. Her neonatal course included veno-arterial extracorporeal membrane oxygenation (ECMO), CDH repair, Nissen fundoplication, gastric tube placement, failed extubation and respiratory failure leading to tracheostomy and long-term mechanical ventilation. The infant was unable to appropriately interface with the ventilatory support and she developed frequent asynchronous episodes resulting in hypoxemia and respiratory acidosis. In addition to cohorting care, attempts to manage these episodes included comfort measures, hand ventilation, manipulations of the mechanical ventilator parameters and mode, increased dose of continuous intravenous (IV) sedation, increased frequency of rescue sedation and, finally, the addition of continuous IV neuromuscular blockade. At 5 months of age, on day 33 of positive pressure ventilation, we considered APRV as an option to improve the respiratory status and achieve a balance between ventilatory and sedation needs. The neurmuscular blockade was discontinued prior to changing the mode of ventilation from SIMV to APRV, and infusions of morphine and versed were maintained constant.

Day of ventilation	Mode	Exhaled V_E (cc/kg/min.)	MAP (cm H_2O)	Maximum/ Minimum FiO_2	pH	CO_2	PaO_2	Sedation rescue # doses/day
32	SIMV	232	28	0.50-0.33	7.31	79	60	4
33	APRV	191	29	0.45-0.30	7.53	61	66	3
34	APRV	215	26	0.50-0.30	7.46	55	63	1

Discussion: After the transition to APRV, the infant became more comfortable. IV infusions of morphine and versed remained constant and her need for rescue doses of sedation decreased over the next few days. Neuromuscular blockade was never restarted. Acidosis and hypoxemia improved on APRV within two days without significant changes in mean airway pressure (MAP), minute ventilation (V_E) or FiO_2. Ventilator settings remained relatively constant for 20 days prior to beginning the weaning process. After 3 months of positive pressure ventilation utilizing APRV, the patient was successfully weaned to CPAP and discharged to home. **Conclusion:** APRV provided adequate ventilation and oxygenation without the need for additional sedation in this infant with severe CLD.

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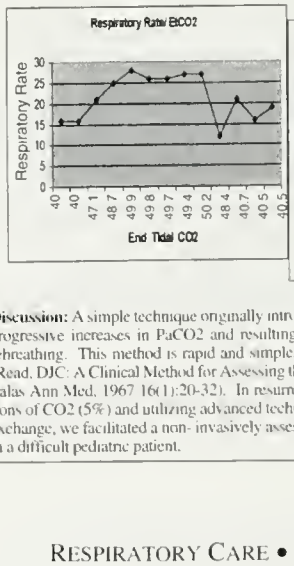
OF-01-215

CASE REPORT: A NON-INVASIVE TECHNIQUE OF HYPEROXIC HYPERCAPNIC CHALLENGE IN A PEDIATRIC PATIENT Timothy Cox, RRT, Aaron Chidekel, M.D., John Rendle, RRT, Jeffery Malatack, M.D.; A. I. duPont Hospital for Children, Thomas Jefferson Medical College, Wilmington, De.

Introduction: If central neurological mechanisms are not depressed, tidal volume and frequency of ventilation increase, when subjected to a rise in carbon dioxide tension (CO_2). We describe a simple procedure using a respiratory profile monitor and gas supply of 5% CO_2 / 95% O_2 to assess the central neurologic response to an increased level of CO_2. **Case Summary:** A 2.5 year old white male with global developmental delay was admitted due to questionable episodes of seizure activity. The patient had a past medical history of rigidity and cyanotic episodes since the age of two months age. Throughout his life the patient was hospitalized for four previous admissions with episodes. A pulmonary consult was obtained to access respiratory control. In addition to polysomonogram a Hyperoxic Hypercapnic Challenge was performed using 5% CO_2 and 95% oxygen. After sedation with Chloral Hydrate, pulmonary mechanics were recorded using a CO2SMO Plus, Respiratory Profile Monitor (Novametrix Medical System, Inc., Wallingford, CT) and continuous cardiac and pulse oximetry monitoring. The procedure was performed in the Pediatric Intensive Care Unit with continuous attendance of two respiratory therapists, a sedation nurse and an attending Pediatric Pulmonologist. A mask was used to create a seal although an intermittent leak was evident. As shown in the accompanying figures an appropriate response in respiratory rate and minute ventilation was recorded in response to increasing levels of end tidal CO_2.



Discussion: A simple technique originally introduced by Haldane and Smith in 1862, is based on progressive increases in $PaCO_2$ and resulting stimulation of ventilation, which occur during rebreathing. This method is rapid and simple, and therefore suitable for clinical investigation. (Read, DJC: A Clinical Method for Assessing the Ventilatory Response to Carbon Dioxide: Australas Ann Med, 1967 16(1):20-32). In resurrecting this simple screen with defined concentrations of CO_2 (5%) and utilizing advanced technology to measure pulmonary mechanics and gas exchange, we facilitated a non- invasively assessment of respiratory control in a difficult pediatric patient.

OF-01-237

CHANGES IN THE MECHANICAL VENTILATION OF NEONATAL PATIENTS WITH AIRLEAK FROM 1990 THROUGH 1999 Julie Ballard RRT BS, and John Salyer RRT MBA FAARC. Respiratory Care Services, Primary Children's Medical Center and School of Medicine, University of Utah, Salt Lake City, UT. **Introduction:** We previously published a study of ventilatory variables in neonatal airleak pts in which we demonstrated moderately high PIP and normocapneic blood gases in the 48 hours prior to development of airleak (Preliminary report of ventilation pressures, PCO_2 and neonatal air leak. Respir Care 1994;39 1078). We sought to repeat this study to determine if patterns of ventilation in this population had changed. **Methods:** Data were extracted using a combination of manual and computerized record review that included ventilator variables, blood gases, and demographics. There were two study periods, Jul 1990 to Feb 1994 (study 1) and Jan 1997 to Dec 1999 (study 2). Airleak was defined as radiographic evidence of PIE, pneumothorax or pneumomediastinum. Pts were excluded whose airleak developed prior to admission or as a result of surgery. Time of airleak was established and data were extracted for the 48 hours prior to that. Pts in study 1 were predominantly ventilated using time-cycled, pressure-limited IMV mode (Infant Star), while pts in study 2 used principally time-cycled, pressure limited, flow-triggered SIMV (Bird VIP). Means testing was done using Mann-Whitney U-test with significance established as $P < 0.05$. **Results:** There were 37 airleak pts in study 1 and 34 in study 2. The study 1 pts had a mean BW of 1513g ± 1118, range 468–4460; study 2 had a mean BW of 1450g ± 1114, range 411–4065 ($P = 0.56$). EGA for airleak study 1 was 29 wks ± 6, range 23-40, airleak study 2 was 29 wks ± 6 wks, range 23-39, $P = 0.65$. During the period before the airleak, high frequency ventilation was utilized as follows: study 1, 5 pts, study 2, 9 pts. All data described here are for conventional ventilatory variables only. No Vt monitoring was used in study 1, but the mean Vt during study 2 was 5.76 cc/kg. **Conclusions:** We are clearly using less PIP, more PEEP (and thus more mean airway pressure), less F_IO_2, shorter inspiratory times, and allowing higher PCO_2, while maintaining the same levels of oxygenation during study 2 than study 1. We are encouraged by these findings, although our study design does not allow us to conclude that one ventilatory technique is better than another. It is clear that there have been substantial changes in how these patients are ventilated.

	Study 1	Study 2	P Value
PIP	26 6 (7 7)	23 0 (5.1)	< 0.01
PEEP	4 6 (1 1)	5 4 (1.6)	< 0 01
Frequency	35 9 (18 5)	35.9 (20 4)	0 90
T_I	0.35 (0.06)	0.32 (0 06)	< 0 01
MAP	8 8 (3 1)	9 8 (3 2)	< 0.01
F_IO_2	0 59 (0 26)	0 54 (0 26)	0 01
pH	7 35 (0 09)	7.32 (0 09)	< 0 01
PO_2	56 8 (15 4)	58 2 (24 2)	0 11
PCO_2	40 4 (9 9)	47.7	< 0.01

OF-01-240

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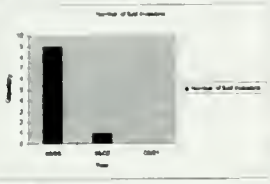
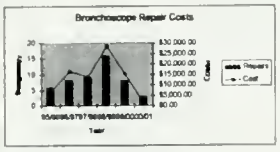
FLEXIBLE FIBEROPTIC BRONCHOSCOPE LEAK DETECTION AND ASSOCIATED REPAIR COST REDUCTIONS

John E. Hahesy MS,RRT,CPFT • Don Renaghan RRT
Respiratory Care Services • Stanford Hospital & Clinics • Stanford, California

Introduction: A progressive increase in the incidence of flexible fiberoptic bronchoscope damage (267% over four years) and associated repair costs prompted a review of handling and damage assessment procedures. Fluid invasions through undetected leaks were noted as the most frequent and costly type of damage. Implementation of a program to detect internal instrument channel and exterior leaks with a Minimus II manometer system (Rudolf Riester GmbH & Co.) eliminated the occurrence of fluid invasions and resulted in a considerable reduction in repair costs. **Methods:** Beginning with fiscal year 1995/96 a retrospective review of the type and frequency of flexible fiberoptic bronchoscope damage was performed. The recurrent type of damage was directly attributable to fluid invasion through the instrument channel. Fluid invasion induced damage created lens impaired image quality and CCD chip failure that contributed significantly to the cost of basic leak repairs. The review also confirmed that fluid invasions occurred through undetected leaks during the preliminary cleaning process. **Implementation:** The Minimus II manometer system for leak detection was acquired and procedural changes to perform dry and wet leak testing prior to cleaning were implemented. All RCP bronchoscopy assistants and supply reprocessing staff were trained in this leak detection procedure. **Results:** Since the implementation of the leak detection program, the incidence of fluid invasions from undetected leaks has been eliminated. In addition, overall costs for flexible bronchoscope repairs directly related to fluid invasion have been significantly reduced.





Conclusion: Early leak detection procedures with a manometer system, including both dry and wet techniques, can greatly reduce concurrent damage to flexible fiberoptic bronchoscopes. Reduction of concurrent damage also translates into significant repair cost reductions. OF-01-041

Spirometry performed by Respiratory Care Practitioners (RCP's) at the bedside to achieve American Thoracic Society (ATS) recommendations

James T. Shreve BS, RRT, RPFT, James P. Lamberti M.D. Inova Fairfax Hospital, Falls Church, VA

Background: Bedside spirometry is provided to perform diagnostic spirometry at the bedside. This allows the patient to remain in their room during testing versus transporting the patient to another area of the hospital for testing. Providing testing at the bedside improves timeliness of diagnostic testing.

Purpose: To assess the improvement of Respiratory Care Practitioners (RCP's) competency performing bedside spirometry to meet American Thoracic Society (ATS) recommendations.

Method: A retrospective review of 58 bedside spirometry reports during a one month period was conducted to determine if bedside spirometry met ATS recommendations for spirometry. The criteria included: spirometry calibration on the day of testing, a minimum of two acceptable maneuvers obtained, three acceptable FVC efforts, the two largest FVC and FEV1 agree within 200 ml, back-extrapolation should be less than 5% or 0.15 L whichever is greater, a plateau in the volume-time spirogram with exhalation time at least 6 seconds or until there is no volume change for at least 1 second. A registered pulmonary function technologist completed the review.

Results: 47% of the spirometry reports reviewed did meet the above-described ATS recommendations. A poster presentation was presented to the staff and instruction provided reviewing the proper technique for performing spirometry. After 90 days a second review of 60 bedside spirometry reports was completed. An improvement of 28% was achieved. ATS recomendations were met in 75% of the patients after additional staff training was provided.

Conclusion: RCP's can provide bedside spirometry that meet ATS recommendations with proper training and continuing education and competency. An ongoing quality control program can ensure accurate data is obtained in the majority of patients.

OF-01-042

THE VALUE OF RCP ASTHMA/COPD CASE MANAGERS, A RANDOMIZED CONTROL TRIAL, **Joe Dwan, MS, RRT, Kaiser Permanente, Portland, Oregon.** Training 2 RCPs began in 1999 with pts starting Jan 2000. Protocols, patient selection criteria, discharge criteria were established for targeted ER patients at two ERs. Randomized control trial (n=60) comparing 12 months data prior to RCP case management and 12 months after the ER date were measured in both the case managed group and the control group. Utilization, including ER & doctor office visits were measured. Cost savings were also calculated. METHODS: HMO patients with adult asthma or COPD who entered one of two ER's had their electronic medical records reviewed by RCPs. Pts were stratified thru selection criteria which eliminated pts <17 yo or >80 yo. Hx CA or drug abuse & those with no phone, MD approval was obtained. Initial clinic visit with RCP case manager included assessment, PFTs, education, action plan, & medication management. Case management was directed by our asthma & COPD Clinical Practice Guidelines, which are standards of care. Follow-up included phone calls & visits as needed. All pt encounters were documented in electronic medical record. Outcomes data collected by review of electronic medical record. Control Groups were identified for the same time period for matched characteristics.

	# Patients Seen by CM	Clinic Visits 12 mos Prior to CM	Clinic Visits After CM	ER Visits 12 mos Prior to CM	ER Visits After CM
1st Quarter	15	50	26	24	0
2nd Quarter	15	28	10	20	0
Totals	*30*	*78*	*36*	*42*	*0*
Control Group Data					
1st Quarter	15	47	48	20	24
2nd Quarter	15	41	54	16	13
Totals	30	88	102	36	37

RESULTS: Significant decrease in ER utilization in the treatment group over the control group was realized. In the 12 mos following the initial visit, ER visits decreased by 100% in the case managed group compared to a 3% increase in the control group. Clinic visits in the treatment group decreased by 54% compared to a 16% increase in the control group. Costs for 16hrs/wk of RCP case management was calculated and then subtracted from the cost savings realized from the decreased utilization of ER, doctor visits and hospitalizations. A cost savings of $49,364 from an investment of $7494 was realized. CONCLUSION: Asthma & COPD case management by RCPs has a significant impact on ER & clinic utilization over a 12 month period. The value of RCP case managers can be documented in health care cost savings and improve quality of care, which can be used to market the RCP case managers to health care systems. The success of this program resulted in expanded RCP case management hours.

OF-01-100

Effects of a Multidisciplinary Task Force Effort to Improve the Process of Adult Mechanical Ventilator Transfers Out of the Acute Care Setting. Greg Sandman, MD, Cathy Gilbert, RN; Matt Kilroy, BS, RRT; Joan Keith, MSW; Deb Ryan, RN; Spectrum Health, Butterworth Campus, 100 Michigan NE, Grand Rapids, Michigan, 49503.
Background: For the last several years there was a concern regarding increased time, expense and poor coordination of mechanically ventilated patients that were identified as non-weanable. Medical Critical Care, Spectrum Health Butterworth Campus had 880 admissions in 1999 of which 438 (49.7%) were ventilated at some point during their ICU stay. Data analysis revealed that patients most likely to fail weaning from mechanical ventilation were those who had experienced 14 consecutive or more in-house ventilator days. Reviewing the last four years of in-house data, there were 43 patients in 1997, 47 patients in 1998, 48 patients in 1999, and 31 patients as of May 2000 that met this criteria. Trends indicate that this patient population continues to increase and will most likely result in a significant increase in cost, related to utilization of hospital resources, unless action was taken. **Objective**: To develop and implement a comprehensive and efficient process to successfully transfer a mechanically ventilated adult patient out of the intensive care unit. This included in-house step down units, sub acute care facilities, long term acute care facilities, long term care Ventilator Dependant Unit or the patient's home. **Design**: Key players involved in the current process were identified and asked to participate on a Process Improvement Team (PIT) that would be charged with developing a program that would help achieve the objective. Long term mechanical ventilator patients were identified as those mechanically ventilated > or = 14 days. Monitors were designed around this figure via Project Impact that included; percent of ventilated patients, percent of ventilated patients at the time of admission, the mean LOS of all patients, patient acuity by SAPS II score on all patients, SAPS II Z-Scores on all patients and patients ventilated > or = 14 days, and mean ICU LOS of patients ventilated > or = to 14 days. The first draft of the written program was developed by using an existing pediatric mechanical ventilator discharge program as a template and the American College of Chest Physicians guidelines on Mechanical Ventilation Beyond The Intensive Care Unit. Chest 1998;113(suppl):289S-344S. Final drafts of the written program were completed and the process was tested immediately on those patients that met the criteria. **Results**: Applying this program to our in-house patients as well as resolving issues early on during PIT meetings, resulted in the LOS of these patients decreasing from a mean ICU LOS in 1999 of 26.1 days to 19.9 days during the first quarter of 2001! It should be noted this significant decrease in LOS occurred inspite of an increase in the overall acuity of this patient population. (Acuity by SAPS II scores 1999 = 46.7, 2001 1st quarter = 50.1) The patient, their family, and the ICU staff satisfaction was enhanced and patient care cost were reduced as a result of this initiative. **Conclusion**: Following a team approach and applying a program that would immediately identify and help initiate a discharge action plan for potential long term mechanical ventilation patient candidates, could significantly reduce the LOS and medical expenses for this patient population.

OF-01-118

THE EFFECT OF RESTERILIZATION METHOD ON BIRD PARTNER PROBES

Michael Tracy RRT, Timothy Myers BS, RRT, Robert Chatburn RRT, FAARC
Rainbow Babies and Children's Hospital, Cleveland, Ohio

BACKGROUND: Waveform analysis and pulmonary mechanics are an integral part in current ventilator management. Many ventilators obtain signals for graphics or mechanics through flow sensors. Reliability and accuracy of sensors make a significant impact on decision-making. Flow sensors are single-patient use only, or reusable after resterilization. Our institution utilizes the Bird VIP and their reusable, flow sensor technology in our Pediatric & Neonatal Intensive Care Units. Per the manufacturer, volume accuracy for the Partner probes are ± 10% for neonatal probes and ± 15% for peds probes. The manufacturer recommends that resterilization can be performed either by ethylene oxide (ETO) or by quaternary ammonium compounds (cold) sterilization. The purpose of this study was to compare the observed accuracy and performance characteristics of Bird Partner® Infant and Pediatric Flow/Volume Sensors brand new and after resterilization by ETO and cold sterilization. **METHODS:** New Partner neonatal & pediatric sensors were evaluated for accuracy of tidal volume (Vt) delivery using calibrated syringes. Neonatal flow sensors were tested at Vt of 10, 20, 30, 40 and 50 cc. Pediatric sensors were tested at Vt of 50, 200, 400, 700 and 1000 cc. Five sensors were tested new out of the package for each sterilization method, and each sensor was evaluated five times at each calibrated Vt. Data were then analyzed as a percentage of error against calibrated volumes both new condition and after each of 5 resterilizations. Error was calculated as the difference (measured value – true value) expressed as a percentage of the true value. Mean and standard deviation was calculated for errors across all volumes. Error intervals were calculated as mean error ± 2.31xSD (Resp Care 1996; 41:1092-1099) and interpreted as the expected error for 95% of future measurements at the 99% confidence level. **RESULTS:** Each category in the table below encompasses 125 volume measurements. Data below are lower (L) and upper (U) error limits expressed as % of true value:

	Sterilizations											
Neonatal	New		1st		2nd		3rd		4th		5th	
Volumes	L	U	L	U	L	U	L	U	L	U	L	U
Gas	-10.4	9.7	-19.6	14.0	-17.0	15.4	-18.0	17.2	-15.1	16.6	-15.1	15.9
Cold	-7.6	8.2	-11.7	4.7	-16.4	4.5	-16.6	6.3	-17.7	6.9	-18.0	10.4

	Sterilizations											
Pediatric	New		1st		2nd		3rd		4th		5th	
Volumes	L	U	L	U	L	U	L	U	L	U	L	U
Gas	-2.3	4.9	-5.3	3.0	-3.9	2.1	-4.5	1.1	-6.4	3.3	-4.7	2.6
Cold	-4.6	4.1	-4.8	3.8	-4.1	4.1	-4.9	5.3	-5.0	5.2	-4.3	4.1

CONCLUSION: In this benchtest, Bird neonatal and pediatric sensors were within the manufacturer's stated accuracy new. Neonatal sensors fell outside the manufacturer's stated accuracy with subsequent resterilazation by either method. Pediatric sensors were within manufacturer's stated accuracy for up to five resterilazations by either method.

OF-01-125

THE EFFECT OF STERILIZATION ON FLOW TRANSDUCERS

Michael Tracy RRT, Timothy Myers BS, RRT, Robert Chatburn RRT, FAARC
Rainbow Babies and Children's Hospital, Cleveland, Ohio

BACKGROUND: The purpose of this study was to compare the observed accuracy of three brands of flow / volume transducers (BiCore, Bird & Novametrix) and to determine if they would maintain accuracy after ethylene oxide (ETO) sterilization. **METHODS:** Manufacturers accuracy ranged from 3% to 15%. We set a clinically acceptible accuracy range of ± 10% for uniform consistency in this benchtest. New BiCore (Neonatal VarFlex® Flow Transducer), Bird (Partner® Infant and Pediatric Flow/Volume Sensor) and Novametrix COSMO+ (Neonatal and Pediatric/Adult combined CO flow sensors) were evaluated for accuracy of tidal volume (Vt) delivery using calibrated syringes. Infant / neonatal flow sensors (all brands) were tested at Vt of 10, 20, 30, 40 and 50 cc. Pediatric/adult sensors (Bird and Novametrix) were tested atVt of 50, 200, 400, 700 and 1000 cc. Five different sensors for each brand were tested new out of the package, and each sensor was evaluated five times at each Vt. Data were then analyzed as a percentage of error for both new condition and after each of 5 resterilizations. Error was calculated as the difference (measured value – true value) expressed as a percentage of the true value. Mean and standard deviation was calculated for errors across all volumes. Error intervals were calculated as mean error ±2.31xSD (Resp Care 1996; 41:1092-1099) and interpreted as the expected error for 95% of future measurements at the 99% confidence level. **RESULTS:** Each number in the table below summarizes 125 volume measurements. Data below are lower (L) and upper (U) error limits expressed as % of true value:

	Sterilizations											
Neonatal	New		1st		2nd		3rd		4th		5th	
Volumes	L	U	L	U	L	U	L	U	L	U	L	U
BiCore	-1.5	6.1	0	14.8	-1.0	19.4	-2.1	23.0	-3.8	25.0	-2.7	22.0
Bird	-10.4	9.7	-19.6	14.0	-17.0	15.4	-18.0	17.2	-15.1	16.6	-15.1	15.9
Novametrix	-4.0	5.5	-2.5	4.3	-4.6	5.5	-3.9	4.0	-2.3	4.7	-2.4	8.1

	Sterilizations											
Pediatric	New		1st		2nd		3rd		4th		5th	
Volumes	L	U	L	U	L	U	L	U	L	U	L	U
Bird	-2.3	4.9	-5.3	3.0	-3.9	2.1	-4.5	1.1	-6.4	3.3	-4.7	2.6
Novametrix	-8.1	-2.0	-10.0	-2.0	-8.2	-2.8	-10.0	-2.9	-10.0	-1.9	-8.4	-3.0

CONCLUSIONS: In this benchtest, new Bird and Novametrix pediatric/adult probes are within our predefined ±19% accuracy range and remain within range for 5 resterilizations. Neonatal probe accuracy is less stable then pediatric probe accuracy. New Novametrix neonatal probes are within our predefined ±10% accuracy range and remain within range for 5 resterilizations. New BiCore and Bird neonatal probes are within our predefined ±10% accuracy range, but fall outside the accuracy range with the 1st resterilization.

OF-01-126

RESPIRATORY DISCHARGE PLANNING-A MULTIDISCIPLINARY APPROACH

FORMOSA, ATANASIO V, BA, RRT MARKS, ALAN RRT, HEALY, MARYANN MSN, SHERMAN, MICHAEL M.D., SCHULMAN, EDWARD M.D. PATRICK, HERBERT M.D.
HAHNEMANN UNIVERSITY HOSPITAL – TENET, BROAD AND VINE STREETS PHILADELPHIA, PA 19102

We reviewed discharge planning performed by Case Management for a six month period in cases where only respiratory services were required. The analysis demonstrated a mean discharge time of 12.4hrs, a minimum discharge time of 4hrs. and a maximum time of 24hrs (n=90 patients). The statistical mode (the time which occurred most frequently to discharge) was 10.0hrs. The Department of Respiratory Care, the Division of Pulmonary and Critical Care Medicine, as well as Case Management formed a multidisciplinary team (January 2001) in order to expedite discharge of patients requiring respiratory home care. All respiratory home care referrals were processed through the Department of Respiratory Care as initiated by contact by physicians or Case Managers. Respiratory home care is completed with patient discharge within 0.5 hrs. Our mean was 1.98hrs, the minimum was 0.5hrs and the maximum duration for discharge for patients requiring extraordinary Life-Care Devices necessitating family and patient inservicing was 24.0hrs(i.e.mechanical ventilation, NIPPV). All Durable Medical Equipment (DME) providers were JCAHO accredited. Only Respiratory Therapists were utilized for initial and follow up site visits at the patient's residence. A quality Assurance questionnaire was delivered to all patients and their families for monitoring services provided, including home instruction, "hands-on" training, and a competency return demonstration. DME companies provided us with follow-up information, including the patient's condition, progress, modifications of therapy, or lack of compliance.

STATISTICAL SUMMARY	RESPIRATORY CARE	CASE MAGEMENT
MEAN	1.98hrs	12.4hrs
MAXIMUM	24.0hrs	24.0hrs
MINIMUM	0.5hrs.	4.0hrs
RANGE	23.5hrs.	20.0hrs
MODE	0.5hrs	10.0hrs

In conclusion we have identified a cohort multidisciplinary model that reduced patient length of stay by one-day; expediting the discharge process and improving the quality of respiratory home care. We have also demonstrated physician/patient satisfaction, deployed a QA process, and joint patient family education. Cost analysis (labor expenditure, indirect costs) for an average hospital day (Discharge after 1100a.m.) translates into a considerable savings and bed turn around time, for our institution Further follow-up will be needed to assess continued outcome measures and track statistical targets.

OF-01-149

INFORMATION AVAILABLE AT THE BEDSIDE OF VENTILATOR PATIENTS IN THE ADULT INTENSIVE CARE UNIT

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Introduction: The abundance of information typically available in the ICU has been the topic of frequent discussion. However, to date, no one has quantified or categorized the information potentially availabe to the respiratory therapsit (RT) at the bedside of an adult ventilator patient in this setting. Realizing that a complete listing of all these individual bits of information might be useful to educators writing case studies and teaching ventilator management, managers looking at time and staffing issues, and bedside clinicians, we compiled such a list.

Methods: Using the modified Delphi technique, three RT students in their last semester were asked to develop a list of all information available to the RT at the bedside of a ventilator patient. Their lists were to be based on personal observation and experience in at least two different adult ICUs, using standard volume ventilators (e.g. P-B 7200). After the first lists were compiled, the group met and, with the help of a facilitator, pared the list down. This procedure was done three times. After the third compilation and paring of the list, it was then put into its final form by the facilitator.

Results: The final list consists of ninety-eight separate items of directly observable information distributed among the following five categories: ventilator function, patient/ventilator interface, patient, external monitors, and immediate patient environment. In addition, a sixth category of communicated information (e.g. medical record, other caregivers, etc.) consisted of at least ten separate information items.

Discussion: The results indicate that the RT must evaluated and assimilate a substantial amount of information every time he/she approaches a patient receiving ventilatory support. How many of the ninety-eight items the individual RT actually considers during any single patient encounter has yet to be studied, and probably varies from patient to patient. In addition, this study only looked at adult ICU patients. The list would probably be shorter for ventilator patients in post-acute care environments, and longer for neonatal/pediatric patients, and patients receiving non-conventional forms of ventilatory support (e.g. jet ventilation, etc.).

OF-01-160

IMPLEMENTATION OF LOW VOLUME VENTILATION FOR ARDS PATIENTS IN A TERTIARY CARE FACILITY. - Mark Turley CRT, Allyson Callahan BS RRT, Anne Freel RRT, William Linane RRT, Nancy Collar BA RRT, Michael Lavery RRT, James Lamberti MD. Inova Fairfax Hospital, Falls Church, VA

BACKGROUND. In May of 2000, the National Heart Lung Blood Institute's Acute Respiratory Distress Syndrome Network (ARDS Net) published a study in the New England Journal of Medicine. The report concluded that the application of a low tidal volume (V_T) ventilation strategy could significantly reduce mortality in ARDS/Acute Lung Injury (ALI) patients. METHOD: We undertook a QI project with our Pulmonary Medicine section comparing ventilation in ARDS/ALI patients with those of the ARDS Network trial. The published trial data was introduced to the Pulmonary, Medicine, and Surgical sections of physicians, as well as the Respiratory Care Practitioners (RCPs). During a three-month period, we reviewed records of all patients in our Intensive Care Units (ICUs) to determine whether they met ARDS/ALI criteria (chest radiographs, PaO_2/FiO_2 ratio, and risk factor). RCPs calculated the ideal body weight (IBW) on all patients who met these criteria, and then encouraged physicians to follow the ventilation protocol using 6cc/kg V_T. We then analyzed an additional three-month period to determine (i.) whether there was any improvement from the initial study baseline and (ii.) where education needed to be applied to improve treatment protocols. RESULTS: We noticed that we needed a more directed education program to improve the way we ventilated ARDS/ALI patients.

Outcome	Day	Education	Mean (SEM)	*p*-value	Outcome	Day	Education	Mean (SEM)	*p*-value
Tidal Volume	1	Pre (N=16)	9.4 (05.7)	*0.85*	Plateau Pressure	1	Pre (N=14)	25 (2.0)	*0.42*
		Post (N=16)	9.6 (0.42)				Post (N=16)	23 (1.3)	
	3	Pre (N=16)	9.2 (0.56)	*0.28*		3	Pre (N=13)	29 (2.8)	*0.28*
		Post (N=15)	8.3 (0.53)				Post (N=14)	26 (1.6)	
	7	Pre (N=10)	9.4 (0.44)	*0.22*		7	Pre (N=9)	36 (2.2)	*0.006*
		Post (N=8)	8.1 (1.0)				Post (N=7)	24 (2.8)	

CONCLUSIONS: With this information we will be able to improve the management of ARDS patients at our facility. This project will allow us to concentrate and improve our educational needs.

OF-01-167

Continued Value of an Adult and Pediatric Utilization Review Program

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Background: Intermittent respiratory care (aerosol therapy, bronchial hygiene, and lung inflation) constitutes the majority of respiratory care orders in many hospitals Unfortunately, these therapies are often inappropriately ordered. This can result in significant cost and service overruns that do not improve clinical outcome. Our Adult and Pediatric Respiratory Care Utilization Review Programs were developed to address the following needs: (1) continuously monitor and evaluate the quality and appropriateness of intermittent respiratory care; (2) pursue opportunities to improve care on a continuous basis which reduce cost but ensure high quality, and (3) ensure physician/therapist compliance to the approved utilization guidelines. We report on the impact of an aggressive, Respiratory Care utilization review program in a tertiary care medical center.

Method: Continuous, prospective review of respiratory care orders for intermittent therapy (bronchial hygiene, aerosol therapy, lung inflation) in pediatric and adult acute care environments (9/99 – 3/01)). Evaluate adherence to Medical Staff approved guidelines for intermittent respiratory care modalities, and monitor most common reasons for change in ordered care.

Results:

	# Orders Reviewed	Orders Reviewed/ Total Orders	Orders Changed/ Orders Reviewed	Orders DC'd	Frequency Reduced
Peds	2817	2817/3535 (80%)	2142/2817 (76%)	19%	53%
Adult	2521	2521/3480 (72%)	1096/2521 (43%)	46%	33%

Over 70% of all intermittent respiratory care orders were reviewed for appropriateness and adherence to departmental guidelines. More orders were changed in the pediatric area than the adult area. The two major changes in care were discontinuation and frequency reduction. In 1989, our department implemented the UR program beginning in the Adult arena. Fiscally, the impact was a 40% reduction in the cost of providing Respiratory Care Services. Based on the data from the study period, the UR program resulted in savings of $234,000.

Conclusion: Intermittent respiratory care orders require diligent respiratory care utilization review and monitoring. Continual monitoring of utilization practice results in significant cost avoidance in both adult and pediatric clinical areas. Continuing efforts should focus not only on UR controls, but also on educational efforts to change the ordering practice of physicians

OF-01-205

INTERDISCIPLINARY CO TREATMENTS OVERCOME OBSTACLES TO PATIENT RECOVERY

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This case involves a 51-year old female with a history of chronic medical problems experiencing a rapid exacerbation of symptoms with severe functional decline. She was sent to both university hospital and diagnostic hospital settings, but a definitive diagnosis could not be made. Some provisional diagnoses were polymyositis, dermatomyositis and ciliac sprue. This is an unusual case because the patient presented at Madonna Rehabilitation Hospital in a completely dependent condition of an unknown etiology. Her lack of bed mobility was so severe she needed assistance to simply move her head. She was in pain and totally dependent on the ventilator. In spite of her poor functional status, she was alert, concerned, and frustrated with the lack of progress she made through several hospitalizations. This case study is important because it illustrates how an interdisciplinary approach can overcome even the most dramatic obstacles to patient recovery. Respiratory therapy (RT) took a leadership role with the team members by implementing co-treatment approaches with physical therapy (PT), occupational therapy (OT), speech-language pathology (SLP), and neuropsychology. The respiratory therapist instructed the team members on how to monitor oxygen saturations and respiratory status so they could safely progress therapies. Co-treatments were often scheduled with team members and throughout many PT and OT sessions, RT's monitored $ETCO_2$ work of breathing, and O_2 saturations. The neuropsychologist would also co-treat to help reduce patient anxiety as new interventions were introduced. The RT and SLP scheduled co-treatments to work on oral motor and laryngeal exercises and interventions with a speaking valve to enable the patient to communicate more easily. The rehabilitation literature indicates that co-treatments provide an efficient means of treatment. In this case study, team members found that co-treating and use of an interdisciplinary approach were the keys in solving recovery obstacles that could not be overcome by a traditional medical approach. The patient has fully recovered and returned to the community, driving her car and engaging in community activities.

OF-01-203

RESPIRATORY THERAPISTS' PARTICIPATION IN ALI/ARDS RESEARCH

Lori Hand, BSc, RRT, CHT, RRCP, Maureen Meade, MD, FRCPC, MSc, Deborah Cook, MD, FRCPC, MSc, France Landry, RRT, RRCP, McMaster University, Hamilton, ON; Brad Elms, BA, RRT, RRCP, Hamilton General Hospital, Hamilton, ON; Scott Helderweirt, RRT, Ilsa Jessup, RRT, St. Paul's Hospital, Vancouver, BC; Rod MacDonald, RRT, RRCP, Courtney Maguire, RRT, RRCP, Mount Sinai Hospital, Toronto, ON, Canada

BACKGROUND: Staff respiratory therapists play an enormous role in the conduct of clinical research in ALI and ARDS. Their attitudes toward participation in this research may influence the successful conduct of clinical trials. We wished to explore bedside respiratory therapists' attitudes towards clinical research in ALI/ARDS and methods for improving their research experience.
METHOD: We conducted an anonymous, self-reported mail survey of bedside respiratory therapists at 4 university affiliated ICUs in Canada. We asked how existing environmental and study related factors affect the respiratory therapists' present research experience, and what factors might contribute to a positive research experience. We also asked for demographic information that might influence survey responses.
RESULTS: In all ICUs where the surveys were conducted, respiratory therapists are accustomed to participating in ALI/ARDS research. We received 53 completed surveys of 66 surveys mailed (80.3% response rate). 92.5% of respondents care for patients enrolled in an ALI/ARDS study, most commonly, 1 to 4 days per month. 7.5% of respondents had not cared for a patient enrolled in an ALI/ARDS study and were not required to complete the survey, other than supplying demographic information. Generally, the respiratory therapists feelings about adhering to a study protocol for mechanical ventilation ranged from neutral to positive. Being involved in research is viewed as an opportunity to learn and is a positive experience. Factors that contribute positively to the research experience include: updates about the progress of the study, periodic in-services, incentives, reminders about required tasks, constructive feedback about performance, and statements of gratitude. Attitudes of physicians and nurses towards a study were documented, as well as how their degree of enthusiasm contributes to the respiratory therapists' research experience. Good organization of manuals, data forms and other materials along with availability of research personnel contribute highly towards a positive research experience. All respondents indicated that the study they had most recently been involved in was the Canadian "Lung Open Ventilation Study" (LOVS).
CONCLUSIONS: Through this survey of attitudes of respiratory therapists' participation in ALI/ARDS research, the vast majority voiced their research experience as a positive one. Numerous modifiable factors appear to contribute to this positive experience. Given the importance of respiratory therapists to this field of research, we believe that this information may be helpful in optimizing the conduct of clinical trials in ALI/ARDS.

OF-01-214

Patient Safety and Staff Satisfaction Following Conversion to Masimo SET Pulse Oximetry – Experience in the Neonatal ICU

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Introduction – Patient safety has always been a concern. Recent reports highlight the importance of human and system error on patient safety [1]. In addition, to the stress placed on staff and the resultant latent errors, monitor function causes other problems in the Neonatal ICU (NICU) with noise from alarms as well as increased handling of the infants to obtain reliable monitoring signals [2,3]. It has been demonstrated that even minor changes in noise and activity in the NICU can affect infant's physiology and well being [3]. We evaluated the impact of a new oximetry technology on staff perception of patient safety and stress levels.

Methods – We converted all oximetry technology in our 39 bed level III NICU to Masimo SET oximetry. Following this a survey was developed to assess factors related to patient safety and staff satisfaction and was administered to RNs, RRTs and MDs in our NICU, 23 clinicians responded. Questions were designed for clinicians to respond to each with either disagree or not disagree with the statement. The following questions were asked: (1) The noise level in the Nursing unit is reduced now compared to before conversion to Masimo oximetry, (2) Changing to Masimo oximetry has resulted in less handling of infants to "fix or adjust" sensors in order to obtain reliable saturation values, (3) I have a greater sense of patient safety since changing to Masimo oximetry, (4) The combination of decreased false alarms and increased confidence in oximetry values has resulted in less distractions while caring for other infants, (5) I have a greater sense of monitoring reliability since changing to Masimo oximetry, (6) The combination of decreased false alarms and increased confidence in oximetry values has resulted in a reduction in staff stress levels, (7) Since changing to Masimo oximetry there has been less parental anxiety concerning the frequency of false alarms and the reliability of the monitor, (8) If I were to transfer to another nursing unit, I would encourage that unit to use Masimo oximetry. Chi-square analysis was used to test the distribution of results, $p < 0.05$ was considered significant.

Results – The results of this survey are tabulated below. These results were significantly different from a random distribution, $p < 0.001$.

Question number	1	2	3	4	5	6	7	8
% not disagreeing	70%	96%	91%	83%	83%	74%	78%	83%
% disagreeing	30%	4%	9%	17%	17%	26%	22%	17%

Conclusions – After having used Masimo SET pulse oximetry in our NICU, our staff perceive greater patient safety and staff satisfaction from this new technology. A significantly greater number of staff members agreed that Masimo oximetry technology offers improved patient safety by agreeing with questions 2 – 5, which were directed at improved patient safety. A significantly greater number of staff members agreed that they would recommend Masimo oximetry if they were transferred to another unit.

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OF-01-224

A COMPARISON OF CORRELATION AND TURNAROUND TIMES OF CBC PERFORMED BY RESPIRATORY CARE PRACTITIONERS UTILIZING A POINT OF CARE TESTING DEVICE (COULTER® ACT DIFF2) TO A CLINICAL LABORATORY DEVICE (BECKMAN GENS).

Stanley M. Baldwin, MBA, RRT, Elizabeth Fischer, RPFT, Daniel G. Walters, M.D., Jonathan Mack, NP, MSN, Glen Grayman, M.D., Departments of Pulmonary and Emergency Services, Desert Regional Medical Center, Palm Springs, CA.

Background: Press-Ganey data shows a strong correlation between patient dissatisfaction and longer emergency department waiting times. Desert Regional Medical Center (DRMC) employed and participated in Health Works consulting consortium with an advisory board from Washington, D.C. Their findings identified several bottlenecks, one being laboratory turnaround. DRMC's actual lab turnaround time (TAT) was on average 62 minutes from order to receipt availability in the ED. Health Works identified that laboratory turnaround could be considered "strong" performance if TAT was 30 minutes or less. To reduce response times, a Beckman Coulter® AcT Diff2 was purchased, capable of a three-part differential and placed in the lab in the emergency department. This device is classified as moderate complex, allowing testing to be done by respiratory care practitioners. All respiratory therapists were given an eight-hour intensive course on physiology and the CBC Hematology Analyzer from the clinical lab with testing for competency. Therapists were trained at the machine site by direct demonstration and observation. Reportable ranges were determined and guidelines set for out of range analysis to be forwarded to the clinical laboratory. The ED lab analyzer was connected to a central information repository via the Cerner Information System. This facilitated computer charges and data from the lab in ED being integrated with clinical laboratory reports under a special heading titled Pulmonary and ED Lab. **Methods:** 37 turnaround times from draw time to availability by computer to the emergency room physicians were selected using a table of random numbers. Correlation between AcT Diff2 in the ED Lab and Gen*S in the clinical laboratory was done by parallel study of 36 whole samples. Regression analysis was performed on WBC's, RBC's, HGB, HCT and platelets to determine correlation coefficients.

AcT Diff2	WBC	RBC	HGB	HCT	PLT
Mean	9.9	3.71	11.5	34.0	235

Gen*S	WBC	RBC	HGB	HCT	PLT
Mean	9.8	3.67	11.6	34.0	228

	WBC	RBC	HGB	HCT	PLT
Mean Difference	0.1	0.04	-0.1	0.0	7

Regression Analysis (r value)	0.997	0.988	0.994	0.988	0.997

	ED Lab	Clinical Lab
Turnaround Time	14	62

Results: The correlation between the devices was high with r being greater than 0.95 on all analytes. The turnaround time for the ED Lab was 14 minutes vs. the Clinical Lab of 62 minutes. This exceeded Health Works benchmark of 30 minutes for strong performance by 16 minutes. **Conclusion:** The use of a point of care device for CBC analysis by trained respiratory care practitioners can reduce turnaround time to physicians improving both efficiency and customer satisfaction while maintaining quality laboratory standards.

OF-01-234

COMPETENCIES ASSESSMENT THROUGH A SKILLS FAIR EVENT

Elsie M.Collado-Koman, BS, RRT, RCP; Timothy Morris, M.D., UCSD Medical Center, San Diego Ca. Background: In our institution we have established a new method of continuously improving and evaluating the respiratory practitioner's skills. To provide ongoing competency assessment we conducted an annual Skills Fair in which all practitioners were tested in the areas such as patient assessment/interaction, technical knowledge, documentation, safety issues, and patient education. Method: Three months before the skills fair a team of respiratory therapists leaders, educators and managers identified specific respiratory care procedures, prioritized by 1) frequency of performance; 2) level of risk; and 3) recent changes in practice guidelines. We separated procedures into those needing direct bedside observation and those that could be assessed in a workshop type setting. Two months before the Skills Fair we began offering inservices and workshops to provide staff the opportunity to review and practice procedures before they were tested. RCPs also received a "Skills Fair Manual" that provided all the information the practitioner was expected to know prior to attending the Skills Fair. It specified what the attendee is expected to verbalize, describe, analyzed, activate, assemble, and disassemble during the activity. Therapists were given answers to 100% of the questions prior to the event. The Skills Fair took place over a three-day period. Each attendee rotated through fifteen stations, performing a specific task and answering related questions. Use of the Skills Fair Manual was not allowed during the actual event. Satisfactory performance was defined as 75% correct performance of the procedures and related questions at each station. In addition, direct bedside observation was required for those skills involving invasive procedures such as arterial puncture, tracheal intubations and bronchoscopy. Results: Seventy-eight respiratory care practitioners attended the Skills Fair. Sixty-three (80%) of the attendees passed all the stations by the end of the event. The fifteen (20%) of the attendees that did not pass were scheduled to attend a review class in the month following the Skills Fair, after which they were reassessed. Overall staff feedback of the activity based on written evaluation was outstanding. Conclusion: A Skills Fair event is a highly effective way to maintain, improve and assess respiratory care skills as well as identify areas where more training is needed. A Skills Fair also offers an excellent 'real-time' method for educators and leaders to increase staff motivation and improve the quality of services provided. Skills Fairs following this model can be adopted in other medical institutions and tailored to suite its specific clinical needs.

OF-01-244

CHANGING TO MASIMO SET PULSE OXIMETRY IMPROVES PATIENT OUTCOME AND STAFF SATISFACTION.

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Introduction: The high incidence of false alarms with standard-type pulse oximetry (SPO) is well documented.[1] In a hospital setting, the use of Masimo SET (MSET) pulse oximetry (Masimo Corp., Irvine, CA) in children has been associated with a reduction of false alarms.[2] MSET has claims of resistance to motion and low perfusion but the impact upon the patient and staff in a sub-acute care setting is uncertain. **Methods:** All pulse oximeters in a sub-acute care facility were changed from SPO devices (Novametrix Medical Systems, Wallingford, CT, models 515B and 520A) to MSET devices (Quartz Medical Q-400, Louisville, CO, containing Masimo SET algorithms). The other change was from use of a semi-reusable PO sensor (Novametrix SuperBight Y-sensor) to the Masimo LNOP adhesive sensors. The nursing, physician and respiratory care personnel remained largely unchanged. The incidence of patient complications and measure of staff satisfaction were tabulated. The patient population using pulse oximeters were ventilator dependent children most of whom were on supplemental oxygen. Continuous pulse oximeter monitoring was prescribed for their routine management and weaning from mechanical ventilation. In this patient population, spontaneous motion frequently causes false SPO alarms. As a result, additional staff time may be consumed to assess the need for increasing the level of ventilatory support and /or oxygen and initiate airway care. **Results:** Matched periods of six-months each compared care in 18 and 21 patients (pre and post-change to MSET respectively). Skin breakdown (including burns) was reduced from 6 pre to none post-change. The staff perceived a > 85% reduction in false alarms and all had greater confidence using MSET during acute procedures (e.g., pulmonary toilet) and sprinting periods (unassisted ventilation endurance challenges). Sprinting was commonly accompanied by significant patient motion. Previously, this would have caused SPO to display suspiciously low SpO_2 values causing the caregiver to shorten the sprinting period, thereby increasing the time for weaning from assisted ventilation. Nurses also commented that there were fewer calls to MDs and RTs related to questionable SpO_2 values. **Conclusions:** The use of the Q-400 with Masimo SET algorithms and LNOP adhesive sensors resulted in improved patient outcomes and greater staff satisfaction compared to use of a standard pulse oximeter. In our sub-acute care setting, there were fewer false alarms, less staff stress, a zero incidence of skin injury, and a greater reliance on pulse oximetry for weaning of oxygen and ventilation.

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OF-01-254

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Respiratory Therapy as Key Contributor to CHF Performance Improvement
Elizabeth Norman, BS, RCP, RRT, Manager Respiratory Services, Julie Harmata-Booth, MS, CPHQ, RHIT, QI/Outcomes Research Facilitator, Providence Holy Cross Medical Center, Mission Hills, California

Background A performance improvement team was formed to focus on Congestive Heart Failure (CHF) length of stay (LOS) While investigating potential issues for increased LOS using a proprietary Internet based data mining program called CaduCIS, the data revealed a high utilization of handheld nebulizers (HHN) in the CHF population admitted to the hospital between 7/1/98 to 6/30/99 For the 299 cases during this period, the mean use was 26 15 by 46 8% of the patients. This was considered high by both the Physician and Respiratory Therapy (RT) team members, especially when the comorbid diagnoses did not justify this utilization. **Plan** RT sampled 30 cases to determine the issues involved It was determined that the reason for the high utilization of HHN's was that the orders for HHN treatment were not being discontinued in a timely way **Do:** RT developed a two prong approach to resolving this issue They communicated the problem to both Medical and Nursing staffs via regularly scheduled meetings In the meetings, they included the fact that if the MD could not be reached to discontinue the order, a note would be left on the chart for the MD to discontinue the order upon documenting after rounds **Check** Initial one year results indicated a 4 97 decrease in mean utilization per patient receiving HHN treatment. A fifteen month review demonstrated and additional 23 decrease in mean utilization which translates into a 5 20 overall increase thus far See table below With continued communication and measurement over the next year, we expect an even greater decrease in mean utilization

CHF		
Date Range 07/01/1998-06/30/1999 (Baseline data)	Total cases on path. 299	
Resource Name	Mean Use	% Patients with Use
HHN TX	26 15	46 8
Date Range 07/01/1999-06/30/2000 (Initial one year results)	Total cases on path 315	
Resource Name	Mean Use	% Patients with Use
HHN TX	21.18	45 1
Data Range 07/01/1999-09/30/2000 (Results- fifteen months)	Total cases on path: 370	
Resource Name	Mean Use	% Patients with Use
HHN TX	20 95	44 1

Act Valuable interactions occur when meaningful performance improvement issues are addressed using sound data by an interdisciplinary team It is estimated that this contribution to the CHF IOP by RT resulted in $100,195 00 less charges annualized with just using the initial one-year results presented

OF-01-255

RESULTS OF USE AND MODIFICATION OF THERAPIST DRIVEN PROTOCOLS RELATIVE TO STAFFING, COMPLIANCE WITH PROTOCOLS, AND MODALITY UTILIZATION. Michael S. Powers, BS, RRT; John W. Farnham, RRT. University of Tennessee Medical Center, 1924 Alcoa Highway, Knoxville, TN 37920. **Background:** The history of therapist driven protocols (TDP) for the delivery of respiratory treatment modalities and of problems associated with inappropriate utilization has been documented in the literature. Our institution first began using TDP to ensure appropriate utilization in 1998. Though accepted well by physicians, quality monitors showed low compliance by respiratory care (RC) staff, a lower than expected degree of modality changes, and some increase in treatment load. We analyzed those variances, took corrective actions (including implementation of respiratory severity scoring tool, staff re-education, and a standardized progress note), and analyzed the results of those actions. Our analysis consisted of spreadsheet comparison of key indicator procedures, staffing patterns, and treatment omissions because of lack of therapist time (LOT) to perform the procedure(s). Additionally, we continued quality monitors of compliance with TDPs. **Results:** Comparison of key indicators after implementation of modifications to TDPs was encouraging. The comparisons of pre-modification versus post-modification within the same calendar year revealed a decrease in small volume nebulizer treatments of 2%, a decrease in intermittent positive pressure breathing treatments by 9%, an increase of metered dose inhaler usage of 529%. Further, there was a 94% decrease in the number of procedures omitted for LOT. Current year to date data represent continued momentum demonstrated by reductions of overall monitored procedures of 14.65%. During the same time period following modification of TDPs and their application, the department experienced a manpower decrease of 8.1 Full Time Equivalents. Workload indicated levels of staffing are now consistently being met. **Experience:** The authors' combined experience includes the initial research into the need for introduction of TDPs, writing and development of protocols adapted specifically for our institution, analyzing performance, and development of modifications in TDP application. **Conclusions:** Use of TDPs can have a positive impact on appropriateness and numbers of procedures. Physician buy-in, RCP compliance, continuing re-education, and ongoing analysis leading to any indicated TDP modification are all essential to the success of TDPs.

OF-01-266

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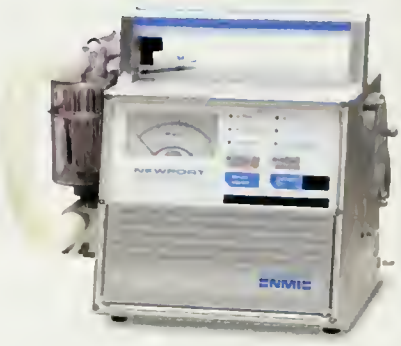

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CASE REPORT: USE OF BILEVEL VENTILATION TO MAINTAIN OXYGENATION AND IMPROVE CO_2 CLEARANCE WHILE TRANSITIONING FROM PCV TO PSV

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Introduction: BiLevel™ (Mallinckrodt PB 840) is a pressure based mode of ventilation that allows unrestricted spontaneous breathing at any point in the mechanical ventilation cycle. It has also been described as a mode in which the patient is allowed to breath spontaneously at two levels of PEEP. In the absence of spontaneous breathing, Bilevel produces a mechanical breath cycle identical to pressure control ventilation (PCV). Benefits of BiLevel include the ability to deliver a pressure based ventilation strategy with improved patient-ventilator synchrony and a decreased need for sedation. **Case Summary:** A 30 year-old male was admitted to our trauma unit following a motor vehicle accident with chest trauma and subsequent development of ARDS. A lung protective strategy of low-frequency PCV[1] was used to support oxygenation while accepting hypercapnea. As the patient's lung injury gradually improved, attempts to transition from PCV to pressure support ventilation (PSV) yielded improved CO_2 clearance yet decreased P_{aO2}/F_{IO2} ratio. The PB 840 ventilator was initiated with BiLevel to allow spontaneous breathing while maintaining a pressure based ventilation strategy. Oxygenation was maintained and even improved with the use of BiLevel. Minute ventilation, and thus CO_2 clearance was augmented with the capability of the patient to superimpose spontaneous, pressure supported breathing. This also allowed the use of lower ventilation pressures for the ventilator mandated breaths. As the patient's lung injury continued to improve, ventilation pressures were further weaned and transition to PSV was well tolerated with eventual removal from ventilatory support. **Discussion:** The advantages of BiLevel in this patient were the ability to maintain a lengthy inspiratory time (I:E ratio) for the ventilator mandated breaths while allowing pressure supported spontaneous breathing at any point in the mechanical ventilation cycle. This strategy maintained oxygenation while allowing spontaneous breathing to augment CO_2 clearance.

Ventilator Management Summary

Day	Ventilator Parameters						pH	P_{aCO2}	P_{aO2}/F_{IO2}
	Mode	$Peak_{aw}$ / PEEP	Freq	I:E	PS	V_E (L/Min)			
#22	PCV	40/14	10	1:1		7.6	7.14	71	255
	PSV	40/14			26	13.2	7.21	53	140
#23	PSV	40/14			26	16.6	7.42	46	131
	BiLevel	30/12	6	1:1	25	12.0	7.35	56	176
#25	BiLevel	28/10	6	1:1	25	13.0	7.44	51	260
#30	BiLevel	24/10	6	1:1	18	10.8	7.34	45	271
#31	BiLevel	20/10	6	1:1	18	13.6	7.38	37	330
#32	PSV	18/10			8	15.4	7.50	30	234
#34	PSV	14/5			9	16.1	7.45	31	328

1. Conrad, SA. Advances in the Management of Respiratory Failure – Advanced Strategies for Mechanical Ventulation in Severe Acute Respiratory Failure. *ASAIO Journal* 1996;42(3):204-206.

OF-01-007

AUTOFLOW IN PCV+ MODE REDUCES PARALYTIC INTERVENTION

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Introduction: The utilization of paralytic drugs has become an essential pharmacological intervention during inverse ratio pressure control ventulation[1]. The setting of a long inspiratory time to elevate the mean airway pressure is often met with deterioration in clinical parameters in the responsive ventulated patient. Historically, ventulators have locked out the patient from breathing spontaneously during the fixed mandatory inspiratory phase which leads to poor patient-ventulator interfacing, reduction in delivered tidal volume, reduced ventulation and oxygen desaturation[2]. The administration of pharmacological paralysis is usually necessary to re-establish patient-ventulator synchrony. The Drager Evita ventulator with Autoflow allows the patient to access flow and interact with the ventilator throughout the inspiratory phase of mandatory ventulation, eliminating the need to administer paralytics. We present a case study that demonstrates this view. **Case Summary:** A fifty-three year old male was admitted with acute pancreatitis. After surgical intervention he was successfully placed on conventional volume ventilation. Later, in the clinical course, he developed sepsis induced ARDS. P/F ratio dropped below 100 and chest x-ray demonstrated bilateral pulmonary infiltrates. Pressure control ventilation was instituted with an inspiratory time of two seconds. Pharmacological paralysis was initiated to maintain patient ventilator synchrony and adequate levels of gas exchange.Cisatracurium was administered for a total of eighteen consecutive days prior to initiation of ventilatory support with the Evita. During the clinical course, the dosage needed to be increased on a daily basis to maintain the desired clinical endpoints. On the eighteenth day the patient required a rate of 13mcg/kg/minute or 2500mg of paralytic per day to achieve and maintain the desired clinical endpoints. During clinical stabilization several attempts were made to remove Cisatracurium to assess neuromuscular function and patient responsiveness. Each attempt failed secondary to patient-ventilator dysynchrony associated with tachypnea, tachycardia, and oxygen desaturation. After the third failed challenge, the patient was placed on the Evita ventilator in the PCV+ mode with the identical ventilatory parameters. Improved ventilator-patient interfacing allowed discontinuation of the paralytic drug. Throughout the remaining clinical course of mandatory ventilation no re-administration of a paralytic was necessary despite increasing the inspiratory time. Spontaneous interactions were noted during the inspiratory phase of ventilation with no reduction in the mean airway pressure. Weaning of the patient is currently progressing via pressure support. **Conclusion:** Patients with respiratory failure requiring inverse ratio pressure control ventilation need drug free periods during the infusion of paralytic medications to evaluate the neurological status and to reduce the risk of prolonged paralysis when the paralytic is discontinued. Clinical assessment during paralytic administration is critical in evaluating patient responsiveness and neuromuscular function. A long inspiratory time is necessary to maintain an adequate mean airway pressure to insure adequate oxygenation in these patients. Conventional ventilators require patient-ventilator synchrony to maintain adequate mean airway pressure; making the discontinuation of paralytics problematic. Our case demorstrates that use of Autoflow in the PCV+ mode allows patient-ventilator while maintaining mean airway pressure without the utilization of pharmacological paralysis.

1. Luce J. *Acute Lung Injury and the Acute Respiratory Distress Syndrome.* Critical Care Med. 1998;26.369-375.
2. Lachman B. *Open Up the Lung and Keep the Lung Open.* Intensive Care Med. 1992; 18.319-322

OF-01-010

THE UTILIZATION OF THE VOLUMETRIC DIFFUSIVE RESPIRATOR TO IMPROVE OXYGENATION AND CONTROL INTRACEREBRAL PRESSURE.

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Introduction: The management of the patient who presents with a significant intracerebral injury and who later develops pulmonary decompensation can be very challenging. Attempts to promote mucokinesis via pulmonary drainage or external percussion can cause significant increases in the intracerebral pressure (ICP). Pulmonary decompensation leads to poor oxygenation and inadequate ventilation that can contribute to an increase in ICP. Ventilator management, which is directed at elevating the mean airway pressure, can impair cerebral venous blood and play a role in rising the ICP[1]. The challenge that the clinician faces is how to promote good pulmonary hygiene and oxygenation without negatively influencing the ICP. We present a case study in which these clinical endpoints were achieved by utilizing the Volumetric Diffusive Respirator (VDR).

Case Summary: An eighteen year old female who was involved in a MVA was admitted to the Trauma-Neuro unit. On admission the diagnosis of several small punctate hemorrhages was made. The patient responded to noxious simulate but did not follow simple commands, a Glascow Score of nine was assigned. Intubation and placement of an intraventricular drain was inserted for intra-cerebral pressure control. PIO_2/FIO_2 (P/F) rano was 600 and chest x-ray unremarkable upon admission. Pedestrian ventilatory parameters were set to maintain a $PaCO_2$ around 30 torr and FIO_2 of 30% to maintain a PaO2 around 100 torr or P/F ratio 330. Lung compliance was 50cc/cm/H_20. Three days post admission chest x-ray revealed small bilateral infiltrates and the P/F ratio dropped to 200. There was a noticeable increase in ICP and the patient was placed in a chemically induced coma along with aggressive diuresis. Twenty-four hours later bilateral infiltrates were noted on chest x-ray and the P/F ratio dropped to 81 on FIO2 100%. Lung compliance deteriorated to 30cc/cm/H_20. Secretions were noted to be mucopurulent and attempts to facilitate mucus removal with manual hand-ventilation was terminated secondary to increased ICP. Efforts at positioning to enhance pulmonary drainage or perform external percussion were terminated secondary to significant elevations in the ICP. The decision was made to change the ventilator strategy from conventional ventilation and utilize the VDR. Initial parameters were peak inspiratory pressure of 42cm/H_20, PEEP 14cm/H_20, rate of 15, I:1 inspiratory/expiratory ratio and FIO_2 100%. Upon initiation of the VDR secretion removal was enhanced without increase in ICP. Within sixteen hours after initiation of the VDR the P/F ratio increased to 280 on 45% FIO_2. Within thirty-six hours there was a visible decrease in pulmonary infiltrates via chest x-ray. ICP was reduced to an acceptable level. The FIO2 was reduced lower with no reduced in the P/F ratio.

Conclusion: Management of the patient with intracerebral injury and respiratory decompensation is complex and problematic. The VDR provides solutions to some of the problems associated with this type of clinical picture. By providing internal pulmonary percussion via its oscillatory mechanics and improving oxygenation with its diffusive function pulmonary endpoints can be achieved without significant negative effect on the ICP. Davis and associates[2] demonstrated this previously and our case summary supports their findings.

1. Schedl R. *Ventilator Dependent Modification of the Intercranial Pressure Curve.* J Clinical Monitor 1987;3:326.
2. Davis K, Hurst J, Branson R. *High FrequencyPercussive Ventilation.* Problems in Respiratory Care; 1989; 39-47.

OF-01-011

EzPAP™ AN ALTERNATIVE IN LUNG EXPANSION THERAPY

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Background: There are a number of conventional therapies available to re-expand lung parenchyma in patients with clinically diagnosed atelectasis (incentive spirometry, positioning, chest physiotherapy). Intermittent positive pressure breathing (IPPB) has been suggested in cases where patients did not respond to, or could not cooperate with other therapies. EzPAP™ (Positive Airway Pressure Therapy System) might be alternative to IPPB in re-expanding atelectatic lung parenchyma. We therefore, observed eight patients in the Neuro- Intensive Care Unit who were ordered for lung expansion therapy. All patients had either unilateral or bilateral atelectasis. All were on supplemental oxygen of 100% via a facemask and a Misty Ox® high flow nebulizer. The mean oxygen saturations were 90±2%.

Methods: EzPAP™ was administered every2-4 hours around the clock. Therapy was performed first by mouthpiece with supplemental oxygen; and if the patient's saturations fell below the pre-therapy level, EzPAP™ was then administered by facemask with supplemental oxygen. Oxygen flow was (via oxygen flowmeter), maintained to achieve an expiratory pressure of 10-20 cmH2O.

Results: After breathing 10 to 20 breaths on the EzPAP™ system, oxygen saturation increased to a mean of 94±2% in all patients. The mask was removed and the patients were instructed to cough. This sequence was repeated 3 to 4 times. Of the patients that were observed, only one eventually required intubation, due to a change in mental status and unable to protect the airway.

Conclusion: Based upon the preliminary observational findings, EzPAP™ may offer a safe, effective alternative lung expansion therapy in the treatment of atelectasis in critically ill patients. To truly establish a role for EzPAP™ in this area of respiratory care, further randomized studies will be needed.

OF-01-021

HIGH FREQUENCY OSCILLATORY VENTILATION IN ADULTS WITH ARDS

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High Frequency Oscillatory Ventilation (HFOV) has been in use for a number of years in neonates for the treatment of Respiratory Distress Syndrome (RDS) mostly due to a loss of surfactant in the lungs. In Adult Respiratory Distress Syndrome (ARDS), adults also lose surfactant, causing decreased tidal volume (Vt), decreased airway distention and increased airway resistance, resulting in volutrauma. HFOV provides a consistent mean airway pressure (MAP) which in turn recruits alveoli / lung volume that was either infiltrated and/or had become atelectatic. HFOV is described as a respiratory rate of > 150 bpm. HFOV should be used on adult patients when conventional volume ventilation and/or pressure control ventilation have become insufficient enough to maintain adequate oxygenation and carbon dioxide elimination, or peak inspiratory pressures > 45cmH2O and MAP > 22cmH2O in either mode of ventilation. Criteria for HFOV include an Oxygen Index (OI) > 13, in two arterial blood gases (ABG's) within a six hour period (OI = 100 x FiO2 x MAP/PaO2). Place an arterial line and CVP for monitoring pressures and serial ABG's. Maintain a normal Mean Arterial Pressure (minimum of 60mmHg) and CVP should be 15-20mmHg. Starting parameters for HFOV are as follows: FiO2 at 100%, MAP started at 4-8cmH2O > MAP on CMV mode of conventional ventilation, and increased by increments of 1-2cmH2O to achieve optimal lung volume. Optimal lung volume is reached once there is an increase in SpO2 enabling a decrease in the FiO2, and a CXR reveals the right hemidiaphragm at the T9-9.5 level with clear lung fields. Flow rate at max flow of 40 lpm. Frequency starts at 6 Hertz (Hz) where 1Hz = 60bpm. The Delta-P or power setting is started at 4.0 and increased until the chest vibrates down to the level of the groin. Percent inspiratory time is started at 33%. The amplitude (which is controlled by Delta-P) can be increased to improve ventilation (CO2 removal) in increments of 5cmH2O. Should the PaCO2 still be high after the amplitude is increased by 20cmH2O, the frequency can be decreased by 1Hz. The goal is to use the highest frequency possible. Slightly deflating the ETT cuff to provide a leak may also decrease PaCO2. The percent inspiratory time should be kept at 33%. However, it may be increased only to decrease PaCO2 or increase PaO2 when Delta-P is maximized and frequency is minimized to 3Hz. The FiO2 can be weaned for arterial saturation > 88%, and once the FiO2 is 40-60% the MAP can be decreased in increments of 1cmH2O. The amplitude is weaned by increments of 5cmH2O for PaCO2 < desired goal. Failure criteria include the inability to decrease the FiO2 by 10% within 24hrs. of institution, or failure to improve or maintain adequate ventilation with PaCO2 < 100mmHg and the pH > 7.15. An OI < 42 at 24hrs. of instituting HFOV is a good indicator of a positive response. Parameters for conversion from HFOV to CMV are: FiO2 < 40%, MAP 15-20cmH2O, and amplitude < 40cmH2O. The success rate for the use of HFOV on adults at Aultman Hospital has been 85% with the key element being early intervention.

OF-01-023

BENCH TEST OF THE DRAGER EVITA 4 VENTILATOR WITH HELIUM-OXYGEN MIXTURES.

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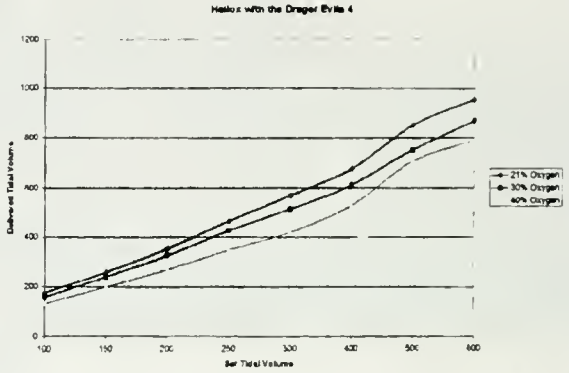
BACKGROUND: We compared the set tidal volumes to the delivered tidal volumes on the Drager Evita 4 ventilator at 21%,30% and 40% Oxygen and Helium mixtures. HeO2 is used to treat patients with upper airway obstruction by promoting laminar flow past the obstruction thus reducing the work of breathing. **METHODS:** All tests were performed with the ventilator in the volume CMV mode, adult and pediatric ranges, flowsensor turned off and removed, and autoflow off. Volumes and Oxygen concentration were measured with a Bio-Tek VT-Plus (Winooski, VT). **RESULTS:** Using 100% Helium connected to the air inlet of the ventilator, it was found that the set and measured tidal volumes were not linear at different HeO2 concentrations.



CONCLUSION: Based on our limited lab evaluation and clinical experience, we feel that the Drager E4 can be safely used in adult and pediatric modes using volume CMV when the flow monitoring is turned off and the flowsensor removed. We now utilize the above chart to determine the delivered tidal volume. Further testing will examine SIMV, pressure support and rise time.

OF-01-024

PRESSURE SUPPORT LEVELS FOR SUCCESSFUL WEANING FROM MECHANICAL VENTILATION - Glen R. Coddington, RCP, RRT

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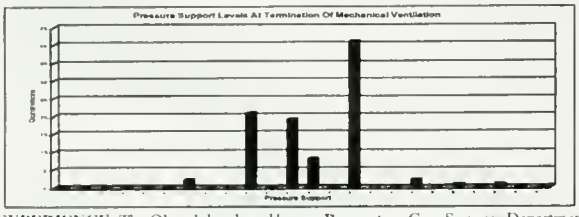
BACKGROUND: A recent study (Am J Respir Crit Care Med 1998 Dec) demonstrated that T-tube trials of a few hours in duration may serve as an indicator of a patient's ability and readiness to be weaned from mechanical ventilation. Another study (N Engl J Med 1995 Feb) utilized the technique of placing the patient on a Pressure Support of 18 cmH2O and then reducing the pressure 2 to 4 cmH20 per day as tolerated. Although both studies suggest that these methods may be somewhat effective, they require additional utilization of Respiratory staffing resources, as well as the associated cost of materials and supplies. **PURPOSE:** To identify and demonstrate an optimal pressure support levels that successfully promote weaning from mechanical ventilation without utilizing labor and time intense T-tube or Pressure Support trials. **METHOD:** A sample population of 100 patients requiring invasive mechanical ventilation were randomly selected and retrospectively reviewed to evaluate what pressure support levels were utilized immediately prior to discontinuing mechanical ventilation. Mechanical ventilation for all patients in the study was performed using the Puritan Bennett 7200AE ventilator. Neonates (<6 months) and "DNR" (Do Not Resuscitate) patients were excluded from the study criteria. However, 2 pediatric patients (ages 15 and 17) that were cared for in our adult ICU were included in the study. Unsuccessful weaning was defined as re-institution of mechanical ventilation within 72 hours and was determined by the patient's clinical presentation and pertinent invasive and non-invasive data.

RESULTS:



EXPERIENCE: The QI tool developed by our Respiratory Care Services Department proved extremely useful for outcome analysis of ventilator management. **CONCLUSION:** There was a 96% success rate when weaning patients from mechanical ventilation utilizing a mean pressure support level of 13.2 cmH20 and this may be a highly effective and less resource alternative to T-tube and Pressure Support trials. However, additional data would be helpful to better suggest which management technique should be utilized for different patient populations. With so many variables involved with the weaning process, it would behoove us as bedside clinicians to note a conclusion that was reached in another study (Crit Care Med 1999 Nov) that stated, "The manner in which the mode of weaning is applied may have a greater effect on the likelihood of weaning than the mode itself."

OF-01-032

Heliox Ventilation in a Dog with Induced ARDS

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BACKGROUND Evidence has suggested that smaller tidal volumes and higher end-expiratory lung volumes may protect adult respiratory distress syndrome (ARDS) patients from further ventilator associated lung injury and may improve outcomes. Heliox (a mixture of helium and oxygen) has been shown to decrease airway resistance in intubated patients, and relieve dyspnea in nonintubated patients. In addition, carbon dioxide elimination is enhanced due to its rapid diffusion through heliox. The purpose of this study was to evaluate whether the use of reduced tidal volume ventilation with heliox in an ARDS induced lab animal would result in improved ventilation and decreased PCO2 levels compared to ventilation with an O2/N2 mixture.

METHODS A trial was conducted on a hound weighing 25 kilograms. Sodium phenoharbital (30 mg/kg) and pancuronium bromide (0.1 mg /kg) were used to initiate anesthesia and paralysis. ARDS was induced by infusing oleic acid (0.12ml/kg) into the right atrium over five minutes. A Siemens 300A ventilator was utilized based on previous studies demonstrating that the use of 80%He/20%O2 with this machine had no effect on delivered tidal volume or FIO2 when used in a volume controlled mode. Initial ventilator settings were tidal volume 300ml (12cc/kg), f-14, 30% O2 and 3 cm PEEP. O2 and PEEP levels were adjusted to maintain oxygenation as the degree of lung injury progressed. Stabilization occurred at a mixture of 70% O_2/30% N_2 with a resultant PaO_2/FiO_2 ratio of <200 confirming ARDS. At this point the dog was alternated between heliox 70%O_2/30% He and 70%O_2/30%N_2 at varying tidal volumes and arterial blood gases were collected and analyzed.

RESULTS There was little difference in pH or $PaCO_2$ between heliox and O_2/N_2 at the various ventilator settings. (see Table)

EXPERIENCE Because of its physical characteristics, we had expected heliox ventilation to be superior. One possible explanation why this did not occur may be related to the moderately low concentration of helium (30%) being delivered. Revisions to our study protocol are being evaluated prior to performing further research.

CONCLUSION The use of heliox did not improve ventilation in a dog with induced ARDS

Mean pH and $PaCO_2$ at Various Ventilator Settings for Heliox vs O_2/N_2

V_T (ml) / PEEP (mmHg)	Heliox pH	O_2/N_2 pH	Heliox $PaCO_2$	O_2/N_2 $PaCO_2$
300 / 7.5	7.10	7.12	60.9	58.6
300 / 10	6.99	6.99	81.0	82.8
200 / 15	6.87	6.87	118.3	130.0

OF-01-039

A NEW VALVED HOLDING CHAMBER (VHC) WITH POSITIVE EXPIRATORY PRESSURE

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Background: There is increasing interest in the application of positive expiratory pressure therapy in conjunction with delivery of medication to maintain airway patency for patients with broncho-constrictive diseases, such as asthma and COPD. Valved holding chambers (VHCs) permit patients with imperfect coordination to use metered dose inhalers (MDIs) effectively and minimize systemic absorption of drug deposited as coarse particles in the upper respiratory tract. We compared the *in vitro* performance of a new VHC with positive expiratory pressure capability (AeroPEP™ VHC, Monaghan Medical Corp., Plattsburgh, NY (n=5 devices)) with that of the AeroChamber Plus™ VHC for the delivery of an anticholinergic formulation (Atrovent®- 18 µg/dose ipratropium bromide (IPR) ex actuator mouthpiece of the pMDI, Boehringer-Ingelheim Pharmaceuticals Inc.).
Methods: Each VHC was washed with an ionic detergent and drip-dried to minimize the influence of electrostatic charge. Measurements of fine particle dose (FPD - particles < 4.7 µm aerodynamic diameter) and total emitted dose (ED) were made with an Andersen 8-stage cascade impactor at 28.3 ± 0.5 l/min, representative of inspiratory flow rates seen in adult patients. 5-doses were initially delivered from a pre-primed and shaken pMDI canister at 45-s intervals directly into the induction port of the impactor (5 replicates). The procedure was undertaken (1 measurement with each VHC), with the door position of the AeroPEP™ VHC set at '0' (minimum positive expiratory pressure), '3' (mid-way) and '6' (maximum). The stages of the impactor and the VHC were then assayed for IPR by HPLC – UV spectrophotometry.
Results:

mean ± S.D

	AeroPEP™ VHC (door position)			AeroChamber Plus™ VHC
	0	3	6	
ED (µg)	13.4 ± 0.6	13.7 ± 0.3	13.3 ± 0.4	11.2 ± 0.7
FPD (µg)	9.4 ± 0.6	9.7 ± 0.3	9.3 ± 0.4	8.6 ± 0.6
FPF (%)	70.2 ± 1.7	70.8 ± 1.0	70.2 ± 1.4	76.3 ± 1.4

Discussion: The door position had no impact on any of the performance measures (1-way repeated measures ANOVA, $p \geq 0.39$. The differences between ED and FPD for the AeroPEP™ VHC (all door positions) and AeroChamber Plus™ VHCs compared to equivalent values for the AeroChamber Plus™ VHCs were small ($p \leq 0.014$) and within the normal range of variability with these devices.
Conclusion: These measurements confirm that the performance of the AeroPEP™ VHC on inhalation was not affected by the presence of the positive expiratory pressure feature that operates only when the patient exhales. OF-01-040

NON-INVASIVE POSITIVE PRESSURE VENTILATION AND OXYGENATION: A CAUTIONARY TALE

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BACKGROUND: Kaiser Permanente's West Los Angeles Medical Center is an acute care hospital serving the HMO's members on the west side of Los Angeles. In 1997, the medical center instituted an aggressive non-invasive ventilator program with the goal that between 10-20% of all mechanical ventilation would be delivered non-invasively. Patients were treated with non-invasive ventilatory (NIPPV) techniques primarily in the hospital's telemetry unit and ICU, although some patients were initiated in the Emergency Department. The equipment used during the study was the Respironics™ ST-D 20 and 30 series non-invasive ventilators. **METHODS:** 71 patients were placed on NIPPV and arterial blood gases were obtained immediately prior to initiation of NIPPV and within one hour after therapy had commenced. A paired Student's T-test was used to evaluate the results. RESULTS: The findings are summarized in the table below (pH, $PaCO_2$, and PaO_2 are mean values):

	Before	After	*p-value*
pH	7.28	7.35	*< .0001*
$PaCO_2$	72.5	59.3	*< .0001*
PaO_2	87.4	69.8	*.0007*

EXPERIENCE: As expected, the patient's pH rose and the $paCO_2$ fell significantly in response to therapy. However, paO_2 also dropped significantly while receiving NIPPV. The rate of success of NIPPV (patient's respiratory failure managed successfully without intubation) for this series of patients was still a robust 80.3%. **CONCLUSIONS:** This is a cautionary tale alerting clinicians to exercise extra vigilance to ensure adequate patient oxygenation during NIPPV. Older BiPAP™ units that deliver oxygen via an external oxygen flow meter "bleed-in" to the patient circuit or mask may not be capable of meeting the patient's oxygen requirements. It is hoped that newer units with built-in air/oxygen blenders will eliminate this dilemma.

OF-01-047

IMPROVED OXYGENATION AND CARBON DIOXIDE ELIMINATION IN AN ADULT PATIENT UTILIZING HIGH FREQUENCY OSCILATORY VENTILATION AND HELIOX.

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Introduction: For several years, HFOV has been used successfully in the neonatal and pediatric patient populations. In addition, anecdotal cases have been reported where HFOV has been utilized in adults weighing >100 kg with favorable results. One possible consequence of using HFOV on larger patients is the ineffective elimination of carbon dioxide. Studies have shown that breathing a helium-oxygen mixture (Heliox) can improve ventilation and increase the removal of carbon dioxide. This case report illustrates the use of a SensorMedics 3100A HFOV in combination with Heliox to sufficiently ventilate an adult patient suffering from ARDS.
Summary: A 47 year old with a seven-day history of mechanical ventilation and necrotic pancreatitis was transported from an outlying hospital to our facility secondary to continued deterioration of respiratory status. He was placed on a Servo 300A and required multiple ventilator adjustments including inverse I:E ratio and optimal PEEP studies in an attempt to improve oxygenation. His pulmonary condition continued to worsen despite increases in FiO2, rate, and Peep. The decision to try HFOV was made. A cylinder containing an 80/20 helium-oxygen mixture was on stand by if needed to decrease the CO2. Patient was placed on HFOV with a resultant increase in PaO2; however, PaCO2 increased (108mmHg) despite adjustments to Delta P, frequency, and Inspiratory Time. Heliox was initiated resulting in a 30% decrease in PaCO2. Patient was stabilized with settings of MAP=20, Delta P=54, FiO2 0.70, frequency 3Hz, and Inspiratory Time 33%. Oxygenation improved allowing the FIO2 and MAP to be decreased. Improved oxygenation allowed for an increase in the delivered helium percentage resulting in further decrease of the PaCO2. The following chart illustrates a sample of ABG's and select ventilator parameters obtained before and during several days of HFOV and Heliox therapy. The following chart illustrates a sample of ABG's obtained before and during several days of HFOV and Heliox therapy.

Arterial Blood Gas	pH	PCO2	PaO2	FiO2	I:E/Ti	MAP	Rate
Pre HFOV	7.46	44	56	0.85	1.5:1	20	15
HFOV- 15 minutes	7.35	61	73	1.00	33	40	6 Hz
HFOV - 2.5 hrs	7.13	108	84	0.90	33	30	4 Hz
Heliox - 2 hours	7.26	76	58	0.90	33	30	4 Hz
Heliox - 5 hours	7.32	72	60	0.72	33	20	4 Hz
Servo 300 - <48 hrs	7.46	44	46	1.00	1.5:1	21	15
HFOV/Heliox >6 hrs	7.44	62	68	0.94	33	14	3 Hz
Heliox – 11 days	7.60	32	58	0.32	33	22	3 Hz

After 11 days, the patient was removed from HFOV and Heliox and placed on conventional ventilation without difficulties.
Discussion In this patient, HFOV was effectively used to improve oxygenation and with the addition of Heliox, was able to drastically lower the PaCO2 while producing no serious effects on machine function. More research is required to determine which patients might benefit from this therapy. OF-01-049

OBSERVATIONS OF A RUPTURE IN THE ALVEOLAR EPITHELIUM DUE TO HIGH VENTILATORY PRESSURES.

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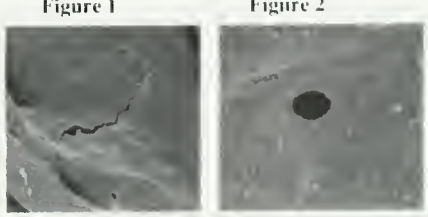
Background: Patients with ALI or ARDS can require high ventilatory pressures to maintain adequate gas exchange. Such pressures may cause damage to the alveolar epithelium and lead to ventilator-induced lung injury (VILI). Currently, the relative roles of inflammation and mechanical stress in the evolution of lung injury are being investigated. The actual damage caused by mechanical stress can be postulated but has not been clearly identified. Using scanning electron microscopy (SEM), we obtained images of lung tissue ventilated under low and high mechanical stress conditions.
Methods: In an isolated, perfused rat lung model, rat lungs were extracted, perfused, and ventilated for 2 hours at a pressure of either Pset=30/PEEP=3 cmH_2O or 20/10 cmH_2O. The lungs were harvested, CPAP of 20 cmH_2O was applied and the lungs were fixed with 3% glutaraldehyde. Random samples of lung underwent SEM preparation using the Murakami and OTO methods followed by critical point drying. Images were captured using a Hitachi S-4700 FESEM scanning electron microscope. **Observations:** Figure 1 - SEM image of alveolar epithelium from rat lung ventilated at 30/3. NOTE: The obvious rupture in the alveolar epithelium. Figure 2 - SEM image of alveolar epithelium ventilated at 20/10. NOTE: An alveolar pore of Kohn identified in lung ventilated at 20/10. Ruptures were not observed in the 20/10 lung.. **Conclusion:** An alveolar rupture can be easily identified by SEM. Using SEM, studies that quantify and locate ruptures may help determine the precise mechanical-stress mechanisms of VILI.

Figure 1 **Figure 2**



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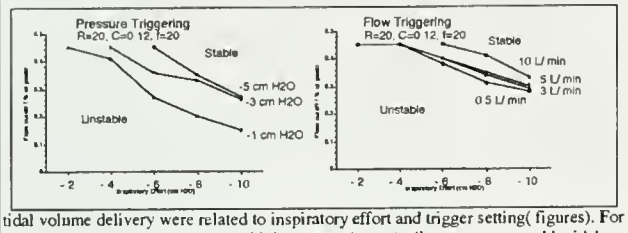
OF-01-061

THE STABILITY OF PARTIAL VENTILATORY SUPPORT MAY BE DETERMINED BY INSPIRATORY EFFORT AND THE SET SENSITIVITY LEVEL. Li Chen PhD, Alexander Adams MPH RRT, Jesus Ong MD, John Hotchkiss MD, Regions Hospital, St. Paul, Univ. of Minnesota, MN

Background: Either pressure or flow sensitivity is set to allow breath triggering in mechanically ventilated patients. The stability of ventilatory support delivered may be related to the coordination of patient effort with the trigger sensitivity settings. However, studies of the effect of both patient effort and sensitivity setting on the stability of ventilatory support have not been reported. In this study, we measured the stability of ventilatory support using a previously reported lung model of obstructive lung disease (AJRCCM 2001; 163: 374-378). We challenged this lung model with a range of effort sensitivity conditions. **Methods:** A mechanical test lung that simulates spontaneous efforts (Hans-Rudolph, Kansas City, MO) was set at R = 20 cm H_2O/L/s, C = 0.12 L/cm H_2O, and f = 20 min^{-1} - an obstructive lung disease condition. The test lung was ventilated with bilevel pressure support (model 840, Mallinckrodt, Carlsbad, CA) - Pset = 22 cm H_2O, PEEP = 5 cm H_2O under a range of inspiratory flow cutoff levels (0.45 to 0.20) and pressure (-1, -3, -5, -10 cm H_2O), or flow triggering levels (0.5, 3, 5, 10 l/min). The inspiratory efforts of the simulated patient were set at -2, -4, -6, -8, and -10 cm H_2O. Instability was defined as a tidal volume delivered over 20 consecutive breaths with a coefficient of variation of > 10%. **Results:** The regions of variable (unstable)



tidal volume delivery were related to inspiratory effort and trigger setting(figures). For each level of pressure or flow sensitivity, areas above the lines represent stable tidal volume delivery while areas below the lines were unstable. As effort decreased, the ventilatory support became more unstable. As the sensitivity level of pressure or flow was set to be less sensitive, ventilatory support became more unstable. **Conclusion:** Patient comfort and the ability to wean from mechanical ventilation may be related to the stability of ventilatory support. In this test lung study, weaker inspiratory effort to trigger the ventilator and a less sensitive trigger setting promoted instability. This study implies that trigger setting and inspiratory effort are related to the stability of ventilatory support.

OF-01-063

NITRIC OXIDE FOR PULMONARY HYPERTENSION ASSOCIATED WITH ARDS

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Introduction Nitric oxide (NO) is a major regulator of vascular smooth muscle tone. When administered via inhalation, NO relaxes pulmonary vascular smooth muscle and is acuvated without altering the systemic bed. In adults with respiratory distress syndrome (ARDS) NO reduced pulmonary arterial pressure and increased oxygenation secondary to a decrease in intra-pulmonary shunting and reduced the pulmonary vascular resistance (PVR)[1]. The clinical utilization of NO has been questioned in the adult population secondary to recent clinical studies[2] **Case Study:** A 28 year-old male hit by a car sustained multiple long fractures along with possible chest trauma Also there was a question of gastric aspiration at the trauma scene. On admission he was quickly intubated and ventilated secondary to respiratory insufficiency Initial arterial blood gas on volume targeted ventilation with 100% O_2 was PH 7.19 $PaCO_2$ 66 torr and PaO_2 192 torr Multiple ventilator parameter changes were made to resolve the respiratory acidosis but the PaO_2/FIO_2 ratio (P/F ratio) dropped to less than 100. Hemodynamic instability was noted and was treated with large volume replacement. Bedside flexible bronchoscopy was performed secondary to periods of oxygen desaturation and to determine degree of gastric aspiration without any change in the clinical course During the next several hours, the mode of ventilation was changed to Pressure Control Ventilation (PCV) with increasing levels of PEEP The P/F ratio remained less than 100. Chest x-ray revealed bilateral infiltrates with noted increased pulmonary vascularity The patient was placed on the Volumetric Diffusive Ventilator (VDR) and PEEP recruitment maneuvers were attempted to improve the P/F ratio. Modest increase in the P/F ratio was noted. Hemodynamic parameters remained unstable with a sustained period of tachycardia along with periods of hypotension A 2-D echogram demonstrated a severe hypokineuc right ventricle with normal left ventricular function. Pulmonary embolus was ruled out via arterial-gram study. PVR elevated to 430dynes\sec/cm and intropic support with dopamine 3mg/kg/min and dobutrex 5mcg/kg/min were administered to maintain a cardiac output greater than 2 L/m. PVR increased to 523dynes/sec/cm and P/F ratio deteriorated to 50. Prostaglandin therapy was started at .1 mcg/kg/min and the PVR dropped to 302dynes/sec/cm. Large volume loading was necessary to maintain an adequate cardiac output above 2 L/m. PVR rose above 350. At this point in the clinical course secondary to elevated PVR and poor oxygenation the decision was made to administer Nitric Oxide(NO) at 20ppm via PCV Prior to NO administration the PEEP was 24cm H_2O with a FIO_2 of 75%. After 10 hours after the start of NO the PVR dropped to 182dynes/sec/cm and cardiac output rose to 3 L/m. P/F ratio increased above 200. FIO_2 and PEEP were reduced to pedestrian parameters The NO was weaned off over the next two days along with intropic support The PVR remained less than 150dynes/sec/cm and P/F ratio greater than 300. Weaning of the ventilator continued to volume targeted ventilation with minimum FIO_2 and PEEP settings. Post NO administration hemodynamics and oxygenation continued to be stable. **Conclusion:** The utilization of Nitric Oxide in the adult patient population has been the subject of much study and debate. Our case presentation demonstrates that there exist clinical scenarios that may respond favorably to its administration. There co-exists the potential for cardiac and respiratory improvement in patients with dual decompensation. In these type of patients NO should be considered if many of conventional modalities have failed to produce the desired clinical end-points.

1. Rossiant R, Falke KJ, Zapol WM. Inhaled nitric oxide for the adult respiratory distress syndrome *N Eng J Med* 1993;328:399-405

2. Micheal J, Barton R, Saffle J, Hinson D, etc. Inhaled Nitric Oxide versus Conventional Therapy *Amer J Resp Critical Care Med* 1998.157:1372-1380.

OF-01-067

CASE SERIES: THREE DIFFERENT PATIENT RESPONSES TO VOLUME SUPPORT MODE

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Introductinn: Volume Support is a support mode of ventilation available on the Siemens Servo 300 ventilator. The patient triggers each breath and the ventilator adjusts the pressure support level, breath by breath, in an effort to match the delivered volume with the preset target volume. Reports on patient response to this mode are limited. In this case series we describe three typical scenarios that we have experienced with its use. **Case #1:** An 85 y/o, 54 Kg male with a history of COPD was placed in Volume Support mode following hip surgery. With initial parameters of .30 FiO_2, 5 cmH_2O PEEP, and 500 mL target tidal volume, the peak inspiratory pressure was 15 cmH_2O, indicating that delivered pressure support was 10 cmH_2O. The patient initially displayed 2 brief periods of apnea and occasional wheezing. These ventilator parameters were maintained overnight while bronchodilator therapy was delivered. The following morning, breath sounds were clear and the patient appeared more alert. Target tidal volume was decreased to 400 mL and peak inspiratory pressure subsequently dropped to 6 cmH_2O indicating a delivered pressure support of 1 cmH_2O. The patient maintained a comfortable respiratory pattern with this level of support and was successfully removed from the ventilator. **Case #2:** A 48 y/o, 80 Kg male with history of hepatic disease was mechanically ventilated following respiratory failure. On day #2 he was placed in Volume Support mode, .30 FiO_2, 5 cmH_2O PEEP, and 600 mL target tidal volume. These parameters were maintained for the next 48 hours with peak inspiratory pressure ranging from 18 to 24 cmH_2O indicating that delivered pressure support varied from 13 to 19 cmH_2O with a delivered tidal volume of approximately 600 mL **Case #3:** A 52 y/o, 152 Kg male with respiratory failure and acute renal failure was being ventilated in the Volume Support mode. On day #6, with ventilator parameters of .40 FiO_2, 6 cmH_2O PEEP, and 500 mL target tidal volume, he was noted to display signs of increased work of breathing. Peak inspiratory pressure was 12 cmH_2O, indicating that delivered pressure support was 6 cmH_2O The ventilator was changed to Pressure Support mode with .40 FiO_2, 6 cmH_2O PEEP, and 15 cmH_2O pressure support. This patient displayed a more comfortable respiratory pattern without signs of distress on these parameters. **Discussion:** Volume Support uses the input of the delivered volume as a feedback to the ventilator's algorithm for adjusting delivered pressure support on the next breath. As in Case #1, the delivered pressure support may be internally weaned to minimum as the patient's respiratory drive returns to normal following sedation or following improvement in lung mechanics. Case #2 represents appropriate maintenance of "maximum pressure support" as the patient's respiratory drive and/or lung mechanics remain depressed. Case #3 represents our experience with Volume Support in a patient with an increased respiratory drive as often seen in anxiety, neural injury, and respiratory distress. If the patient's efforts generate a delivered volume greater than the preset target volume, the ventilator will subsequently decrease the delivered support pressure. This may leave the patient with respiratory distress in a situation of minimal ventilatory support. **Conclusion:** With close observation from the clinician and an appropriate preset target volume, Volume Support can be an excellent support mode However, relying on a single input, delivered volume, to titrate the amount of support is not adequate in all patients.

OF-01-074

VENTILATOR MANAGEMENT OF ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS) BEFORE AND AFTER ANNOUNCEMENT OF THE NIH ARDS NETWORK'S LOW TIDAL VOLUME (V_T) VENTILATION STUDY.

RH Kallet MS RRT, JA Alonso RRT, JM Luce MD, Departments of Anesthesia, and Pulmonary Critical Care Medicine, San Francisco General Hospital (SFGH)

Background: The NIH ARDS Network trial compared traditional V_T ventilation at 12 mL/kg to 6 mL/kg and demonstrated a significant mortality reduction (39 vs. 31% respectively) in ARDS patients. We inquired whether these study results influenced physician ventilator management of ARDS patients. **Methods**: Data was abstracted from the medical records of 37 consecutive ARDS patients treated at SFGH between May and October 1996 (during the first months of the Network study) and 34 consecutive ARDS patients treated from March through August 2000 (approximately 1 year after the study results were made public). No data was used from any patient enrolled into an ARDS Network study, nor in any patient managed clinically using the ARDS Network protocol. Ventilation and arterial blood gas variables were recorded from a reference period on the day European-American consensus conference criteria for ARDS were met, and for 2 days afterwards. Between group (1996 vs. 2000) comparisons were made using unpaired Bonferonni t-tests. Within-group, between-day comparisons were made using one-way analysis of variance and Tukey-Kramer tests. Alpha was set at 0.05. **Results**: V_T was significantly lower and PEEP was significantly higher in patients managed after release of the ARDS Network study results. There was a trend towards a progressively lower V_T over the first 3 days in patients managed during 2000. The end-inspiratory plateau pressure (P_{PLAT}) was not different, but the change in airway pressure (ΔP_{AW}: P_{PLAT} – PEEP) was significantly lower on Day 0 and remained below 20 cm H_2O on subsequent days. Arterial carbon dioxide tension ($PaCO_2$) was different by Day 2. Arterial pH was not different between groups.

1996	Day 0	Day 1	Day 2
V_T (mL)	741± 137	734 ± 129	742 ± 128
P_{PLAT} (cm H_2O)	31.2 ± 9.4	29.8 ± 9.6	27.3 ± 7.2
PEEP (cm H_2O)	6.9 ± 3.4	8.3 ± 3.7	8.0 ± 3.8
ΔP_{AW} (cm H_2O)	26.9 ± 10.5	21.5 ± 7.4	20.3 ± 7.6
$PaCO_2$ (mm Hg)	39.7 ± 11.4	37.6 ± 7.7	37.0 ± 7.0
2000	**Day 0**	**Day 1**	**Day 2**
V_T (mL)	592 ± 139†	546 ± 159†	520 ± 160†
P_{PLAT} (cm H_2O)	27.3 ± 7.2	29.1 ± 8.4	27.8 ± 9.0
PEEP (cm H_2O)	8.6 ± 3.2†	10.6 ± 4.1†	10.6 ± 3.8†
ΔP_{AW} (cm H_2O)	18.9 ± 6.4†	18.5 ± 7.0	17.2 ± 7.5
$PaCO_2$ (mm Hg)	42.3 ± 7.9	40.2 ± 11.6	42.0 ± 9.4†

† $p < 0.05$ compared to corresponding 1996 variable

Conclusion: The ARDS Network study results appears to have influenced clinical practice in a Network study hospital. The higher PEEP level during 2000 may suggest an increased awareness of the potential for added lung protection by maintaining an elevated end-expiratory lung volume. Therefore, these results alternatively may signify a generalized awareness of lung protective strategies in ARDS patients that had increased over time. OF-01-131

COMPARISON OF TIDAL VOLUME (V_T) STABILITY BETWEEN VOLUME CONTROL AND PRESSURE CONTROL VENTILATION (VCV, PCV) USING THE NIH ARDS NETWORK'S LOW V_T PROTOCOL.

RH Kallet MS RRT, JM Luce MD, Departments of Anesthesia, and Pulmonary Critical Care Medicine, San Francisco General Hospital (SFGH)

Background: SFGH has commenced voluntary utilization of NIH ARDS Network low V_T protocol for clinical management of ALI/ARDS patients. The NIH ARDS Network low V_T protocol requires use of VCV to insure that V_T does not exceed the clinical-set target range. However, our institution routinely uses pressure-targeted modes of ventilation when managing ALI/ARDS patients. PCV allows V_T augmentation during either patient-triggered breaths, or conditions of improved lung compliance. Therefore, we inquired whether V_T could be adequately controlled utilizing PCV during clinical management with the NIH ARDS Network protocol. **Methods:** We reviewed data on 14 ALI/ARDS patients managed clinically with the NIH ARDS Network protocol. Four of 14 patients were managed with both ventilator modes on separate days. The corrected V_T (minus compression volume loss) and V_T in mL/kg was recorded for all status reports. In addition, the V_T on the first ventilator status report of the day was used as the reference for determining average V_T variability for that day. An average of 6 ventilator status reports/day were generated and 2 days of data collection on each mode was used for each patient. If adjustments in V_T or pressure control had been made, only data prior to the change was used on that day. Average relative V_T variability/day (± Δ mL) was recorded. Data was analyzed using unpaired Mann-Whitney tests. Alpha was set at 0.05. **Results**: A total of 166 ventilator status reports generated over 17 days of protocol management were reviewed. There were 104 reports over 15 days for VCV and 76 reports over 12 days for PCV. Only 17% of the VCV reports and 5% of PCV reports occurred during patient-triggered conditions.

	VCV	PCV	p
V_T (mL)	372 ± 64	409 ± 95	0.0007
V_T (mL/kg)	5.67 ± 0.68	6.72 ± 1.02	<0.0001
Δ V_T (mL)	15.3 ± 12.0	38.8 ± 19.4	0.0007
Δ V_T (mL/kg)	0.24 ± 0.21	0.62 ± 0.32	0.0011

Conclusion: V_T was higher and more variable during PCV. However the V_T variability during PCV was similar to the average V_T variability allowed by the ARDS Network protocol (± 0.5 mL/kg). However, as the majority of measurements were made during controlled ventilation conditions, these data may not reflect patient-triggered ventilation conditions (i.e.: augmented V_T delivery during PCV or double-triggering during VCV).

OF-01-132

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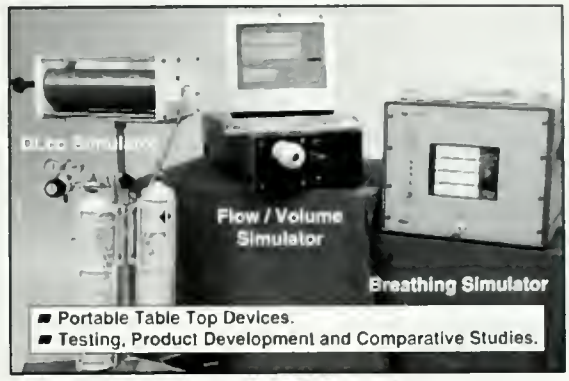

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PRELIMINARY OUTCOME DATA ON ACUTE LUNG INJURY (ALI) PATIENTS MANAGED WITH THE NIH ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS) NETWORK'S LOW TIDAL VOLUME (V_T) VENTILATION PROTOCOL.

RH Kallet MS RRT, JM Luce MD, RM Jasmer MD, AR Campbell MD, J Tang MD
Departments of Anesthesia, Surgery and Pulmonary Critical Care Medicine, San Francisco General Hospital (SFGH)

Background: The NIH ARDS Network trial compared traditional V_T ventilation at 12 mL/kg to 6 mL/kg and demonstrated a significant mortality reduction (39.8 vs. 31% respectively) in ALI/ARDS patients. SFGH has commenced voluntary utilization of this protocol to manage ALI/ARDS patients. We inquired whether a similar mortality rate could be reproduced when the ARDS Network study protocol was utilized for clinical management. **Methods**: We reviewed data on all ALI/ARDS patients managed clinically with the NIH ARDS Network protocol between September 2000 and June 2001. None of these patients was enrolled into any ARDS Network study. Protocol initiation was at the discretion of the critical care services. **Results**: 110 ALI/ARDS patients were identified and 36 were managed clinically with the NIH ARDS protocol. Subsequently, 3 patients were enrolled into an ongoing ARDS Network trial and their data was excluded. ARDS Network exclusion criteria (i.e.: severe chronic liver disease, chronic lung disease, acute brain injury, etc) were met in 12/33 patients with a subsequent mortality of 50%. Only LIS at protocol initiation distinguished survivors from non-survivors (2.63 ± 0.47 vs. 3.0 ± 0.38 respectively; p = 0.035 by two-tailed, unpaired Mann-Whitney test.

Lung Injury Score*	2.78 ± 0.46
APACHE II*	20.1 ± 7.3
SAPS II*	44.4 ± 14.2
Age	43.7 ± 12.1 years
ALI/ARDS Vent Days before Protocol	1.3 ± 1.8 days
Pulmonary vs Non Pulmonary ALI/ARDS	52% vs. 36%†
Hospital Mortality	36% (12/33)
Mortality adjusted for ARDS Net exclusions	29% (6/21)

* based on N =33 and protocol implementation day; † 12% Idiopathic ARDS

Conclusion: Our ALI/ARDS patients managed early in their disease course with the NIH ARDS Network ventilation protocol apparently had a similar mortality rate to the ARDS Network study (once the data was controlled for most ARDS Network study exclusion criteria). Our preliminary uncontrolled data are based upon a very small sample size. Therefore, our data should be interpreted with caution

OF-01-133

EFFECTS OF AUTO-TUBE COMPENSATION (ATC) ON TIDAL VOLUME (V_T) DELIVERY DURING CONTROLLED MECHANICAL VENTILATION

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Background: ATC augments ventilator inspiratory flow rate $\dot{V}_I$ to achieve the proximal airway pressure target at the distal tip of the endotracheal tube (ETT), thus counterbalancing the imposed WOB of the artificial airway. ATC can be activated in all pressure-regulated modes of ventilation. We inquired how ATC may impact V_T and lung pressures in the absence of patient triggering during simulated lung protective ventilation. **Methods**: A Michigan Instruments TTL lung simulator was set at a compliance of 27 mL/cm H_2O and attached to a Dräger E-2 ventilator. Pressure control (PC) and volume control with Auto-Flow (VC-AF) modes of ventilation were studied. Also, pressure support (PS) was used as a reference point to compare the performance of ATC. A V_T of 400 mL at a respiratory rate = 20 was used. During PC and PS, a V_T of 400 mL was obtained with a set pressure = 16-17 cm H_2O. No end-expiratory pressure was used. During PS, breaths were "auto-triggered" by lightly compressing the model bellows, creating a small flow spike that captured the flow trigger threshold (5 L/m). Experiments were done with ATC turned off and at an ATC of 100% compensation set to the ETT size used in the model (7.0 mm ID). Measurements were made with a Ventrak pulmonary mechanics monitor; 10 breaths were used for analysis. The end-inspiratory pressure in the compartment (P_{COMP}) was used as an analog for lung pressure. Pressure also was measured at the distal tip of the ETT at the point of peak airway pressure in the circuit (PAP). Data was reported as mean ± standard deviation and analyzed using repeated-measures analysis of variance and Student Newman Keul tests. Alpha was set at 0.05. **Results**: During PS, ATC increased peak $\dot{V}_I$ and PAP to achieve the preset PS level at distal tip of the ETT. V_T delivery was increased (despite an absence of post-trigger inspiratory effort), thus P_{COMP} also increased. However, during PC, flow augmentation during ATC caused an overshoot in the distal ETT pressure (20 vs. 16 cm H_2O). During VC-AF, ATC caused a transient increase in $\dot{V}_I$, PAP and V_T that was corrected by the ventilator within 3 breaths. As a result, only the comparisons of V_T $\dot{V}_I$ and P_{COMP} (with vs. without ATC) during VCAF were not statistically significant (*p > 0.05).

Mode	V_T (mL)	$\dot{V}_I$ (L/min)	P_{COMP} (cmH_2O)	PAP (cm H_2O)
PSV	428 ± 7	67 ± 0.8	16 ± 0	17 ± 0
PSV + ATC	744 ± 19	88 ± 1.2	25.8 ± 0.8	30 ± 1
PCV	433 ± 2	64 ± 0.7	16 ± 0	16 ± 0
PCV + ATC	699 ± 9	84 ± 1	25 ± 0	29 ± 0.5
VC-AF	425 ± 3*	63 ± 0.4*	16 ± 0*	16 ± 0
VC-AF + ATC	438 ± 84*	61 ± 8*	16 ± 3*	18 ± 4

Conclusion: Our results indicate that ATC increases PAP above the operator-set pressure level. Both V_T and $\dot{V}_I$ delivery are increased (particularly during PCV), even in the absence of inspiratory effort. Therefore, ATC should not be used when strict control of V_T and lung pressure is intended.

OF-01-198

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Exhibitors

at the 47th International Respiratory Congress of the American Association for Respiratory Care

December 1-4, 2001
San Antonio, Texas

Thousands of examples of respiratory care equipment and supplies are displayed, discussed, and demonstrated in the exhibit booths at the International Respiratory Congress. The AARC thanks the firms that support the Association by participating. (Exhibitors confirmed by October 2, 2001 are listed.)

Exhibit Hours

Saturday, December 1	11 AM to 4 PM
Sunday, December 2	11 AM to 4 PM
Monday, December 3	11 AM to 4 PM

Exhibitor	Booth
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MEDWATCH

THE FDA MEDICAL PRODUCTS REPORTING PROGRAM

For VOLUNTARY reporting by health professionals of adverse events and product problems

Form Approved OMB No. 0910-0291 Expires 4-30-96
See OMB statement on reverse

FDA Use Only (Resp Care)

Triage unit
sequence #

A. Patient information

1 Patient identifier
In confidence

2 Age at time of event:
or
Date of birth:

3 Sex
☐ female
☐ male

4 Weight
_____ lbs
or
_____ kgs

B. Adverse event or product problem

1 ☐ Adverse event and/or ☐ Product problem (e.g., defects/malfunctions)

2 Outcomes attributed to adverse event (check all that apply)
☐ death _____ (mo/day/yr)
☐ life-threatening
☐ hospitalization – initial or prolonged
☐ disability
☐ congenital anomaly
☐ required intervention to prevent permanent impairment/damage
☐ other _____

3 Date of event (mo/day/yr)

4 Date of this report (mo/day/yr)

5 Describe event or problem

6 Relevant tests/laboratory data, including dates

7 Other relevant history, including preexisting medical conditions (e.g., allergies, race, pregnancy, smoking and alcohol use, hepatic/renal dysfunction, etc.)

C. Suspect medication(s)

1 Name (give labeled strength & mfr/labeler, if known)
#1
#2

2 Dose, frequency & route used
#1
#2

3 Therapy dates (if unknown, give duration)
from/to (or best estimate)
#1
#2

4 Diagnosis for use (indication)
#1
#2

5 Event abated after use stopped or dose reduced
#1 ☐ yes ☐ no ☐ doesn't apply
#2 ☐ yes ☐ no ☐ doesn't apply

6 Lot # (if known)
#1
#2

7 Exp. date (if known)
#1
#2

8 Event reappeared after reintroduction
#1 ☐ yes ☐ no ☐ doesn't apply
#2 ☐ yes ☐ no ☐ doesn't apply

9 NDC # (for product problems only)
– –

10 Concomitant medical products and therapy dates (exclude treatment of event)

D. Suspect medical device

1 Brand name

2 Type of device

3 Manufacturer name & address

4 Operator of device
☐ health professional
☐ lay user/patient
☐ other

5 Expiration date (mo/day/yr)

6
model # _____
catalog # _____
serial # _____
lot # _____
other # _____

7 If implanted, give date (mo/day/yr)

8 If explanted, give date (mo/day/yr)

9 Device available for evaluation? (Do not send to FDA)
☐ yes ☐ no ☐ returned to manufacturer on _____ (mo/day/yr)

10 Concomitant medical products and therapy dates (exclude treatment of event)

E. Reporter (see confidentiality section on back)

1 Name & address

phone #

2 Health professional?
☐ yes ☐ no

3 Occupation

4 Also reported to
☐ manufacturer
☐ user facility
☐ distributor

5 If you do NOT want your identity disclosed to the manufacturer, place an " X " in this box. ☐

FDA

Mail to: MEDWATCH
5600 Fishers Lane
Rockville, MD 20852-9787

or FAX to:
1-800-FDA-0178

FDA Form 3500 1/96)

Submission of a report does not constitute an admission that medical personnel or the product caused or contributed to the event.

ADVICE ABOUT VOLUNTARY REPORTING

Report experiences with:

- medications (drugs or biologics)
- medical devices (including in-vitro diagnostics)
- special nutritional products (dietary supplements, medical foods, infant formulas)
- other products regulated by FDA

Report SERIOUS adverse events. An event is serious when the patient outcome is:

- death
- life-threatening (real risk of dying)
- hospitalization (initial or prolonged)
- disability (significant, persistent or permanent)
- congenital anomaly
- required intervention to prevent permanent impairment or damage

Report even if:

- you're not certain the product caused the event
- you don't have all the details

Report product problems – quality, performance or safety concerns such as:

- suspected contamination
- questionable stability
- defective components
- poor packaging or labeling
- therapeutic failures

How to report:

- just fill in the sections that apply to your report
- use section C for all products except medical devices
- attach additional blank pages if needed
- use a separate form for each patient
- report either to FDA or the manufacturer (or both)

Important numbers:

- 1-800-FDA-0178 to FAX report
- 1-800-FDA-7737 to report by modem
- 1-800-FDA-1088 to report by phone or for more information
- 1-800-822-7967 for a VAERS form for vaccines

If your report involves a serious adverse event with a device and it occurred in a facility outside a doctor's office, that facility may be legally required to report to FDA and/or the manufacturer. Please notify the person in that facility who would handle such reporting.

Confidentiality: The patient's identity is held in strict confidence by FDA and protected to the fullest extent of the law. The reporter's identity, including the identity of a self-reporter, may be shared with the manufacturer unless requested otherwise. However, FDA will not disclose the reporter's identity in response to a request from the public, pursuant to the Freedom of Information Act.

The public reporting burden for this collection of information has been estimated to average 30 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to:

DHHS Reports Clearance Office
Paperwork Reduction Project (0910-0291)
Hubert H. Humphrey Building, Room 531-H
200 Independence Avenue S.W.
Washington, DC 20201

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service • Food and Drug Administration

FDA Form 3500-back

Please Use Address Provided Below – Just Fold In Thirds, Tape and Mail

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Public Health Service
Food and Drug Administration
Rockville, MD 20857

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The FDA Medical Products Reporting Program
Food and Drug Administration
5600 Fishers Lane
Rockville, MD 20852-9787

American Association for Respiratory Care

MEMBERSHIP APPLICATION

Please read the eligibility requirements for each of the classifications in the right-hand column, then complete the applicable section. All information requested below must be provided, except where indicated as optional. See other side for more information and fee schedule. Please sign and date application on reverse side and type or print clearly. Processing of application takes approximately 15 days.

- ☐ Active
- ☐ Associate
  - ☐ Foreign
  - ☐ Physician
  - ☐ Industrial
- ☐ Special
- ☐ Student

Last Name _____

First Name _____

Social Security No. _____

Home Address _____

City _____

State _____ Zip __ __ __ __ __ — __ __ __ __

Phone No. (_____) _____

Primary Job Responsibility (check one only)

- ☐ Technical Director
- ☐ Assistant Technical Director
- ☐ Pulmonary Function Specialist
- ☐ Instructor/Educator
- ☐ Supervisor
- ☐ Staff Therapist
- ☐ Staff Technician
- ☐ Rehabilitation/Home Care
- ☐ Medical Director
- ☐ Sales
- ☐ Student
- ☐ Other, specify _____

Type of Business

- ☐ Hospital
- ☐ Skilled Nursing Facility
- ☐ DME/HME
- ☐ Home Health Agency
- ☐ Educational Institution
- ☐ Manufacturer or supplier
- ☐ Other, specify _____

Date of Birth (optional) _____ Sex (optional) _____

U.S. Citizen? _____ Yes _____ No

Have you ever been a member of the AARC? _____

If so, when? From _____ to _____

Preferred mailing address: ☐ Home ☐ Business

For office use only

FOR ACTIVE MEMBER

An individual is eligible if he/she lives in the U.S. or its territories or was an Active Member prior to moving outside its borders or territories, and meets ONE of the following criteria: (1) is legally credentialed as a respiratory care professional if employed in a state that mandates such; OR (2) is a graduate of an accredited educational program in respiratory care; OR (3) holds a credential issued by the NBRC. An individual who is an AARC Active Member in good standing on December 8, 1994, will continue as such provided his/her membership remains in good standing.

PLEASE USE THE ADDRESS OF THE LOCATION WHERE YOU PERFORM YOUR JOB, NOT THE CORPORATE HEADQUARTERS IF IT IS LOCATED ELSEWHERE

Place of Employment _____

Address _____

City _____

State _____ Zip __ __ __ __ __ - __ __ __ __

Phone No. (_____) _____

Medical Director/Medical Sponsor _____

FOR ASSOCIATE OR SPECIAL MEMBER

Individuals who hold a position related to respiratory care but do not meet the requirements of Active Member shall be Associate Members. They have all the rights and benefits of the Association except to hold office, vote, or serve as chair of a standing committee. The following subclasses of Associate Membership are available: Foreign, Physician, and Industrial (individuals whose primary occupation is directly or indirectly devoted to the manufacture, sale, or distribution of respiratory care equipment or supplies). Special Members are those not working in a respiratory care-related field.

PLEASE USE THE ADDRESS OF THE LOCATION WHERE YOU PERFORM YOUR JOB, NOT THE CORPORATE HEADQUARTERS IF IT IS LOCATED ELSEWHERE

Place of Employment _____

Address _____

City _____

State _____ Zip __ __ __ __ __ - __ __ __ __

Phone No. (_____) _____

FOR STUDENT MEMBER

Individuals will be classified as Student Members if they meet all the requirements for Associate Membership and are enrolled in an educational program in respiratory care accredited by, or in the process of seeking accreditation from, an AARC-recognized agency.

SPECIAL NOTICE — Student Members do not receive Continuing Respiratory Care Education (CRCE) transcripts. Upon completion of your respiratory care education, continuing education credits may be pursued upon your reclassification to Active or Associate Member.

School/RC Program _____

Address _____

City _____

State _____ Zip __ __ __ __ __ - __ __ __ __

Phone No. (_____) _____

Length of program

- ☐ 1 year
- ☐ 2 years
- ☐ 4 years
- ☐ Other, specify _____

Expected Date of Graduation *(REQUIRED INFORMATION)*

Month _____ Year _____

American Association for Respiratory Care • 11030 Ables Lane • Dallas, TX 75229-4593 • (972) 243-2272 • Fax (972) 484-2720

Demographic Questions

We request that you answer these questions in order to help us design services and programs to meet your needs.

Check the Highest Degree Earned

- ☐ High School
- ☐ RC Graduate Technician
- ☐ Associate Degree
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctorate Degree

Number of Years in Respiratory Care

- ☐ 0-2 years
- ☐ 3-5 years
- ☐ 6-10 years
- ☐ 11-15 Years
- ☐ 16 years or more

Job Status

- ☐ Full Time
- ☐ Part Time

Credentials

- ☐ RRT
- ☐ CRT
- ☐ Physician
- ☐ CRNA
- ☐ RN
- ☐ LVN/LPN
- ☐ CPFT
- ☐ RPFT
- ☐ Perinotal/Pediatric

Salary

- ☐ Less than $10,000
- ☐ $10,001-$20,000
- ☐ $20,001-$30,000
- ☐ $30,001-$40,000
- ☐ $40,000 or more

PLEASE SIGN

I hereby apply for membership in the American Association for Respiratory Care and have enclosed my dues. If approved for membership in the AARC, I will abide by its bylaws and professional code of ethics. I authorize investigation of all statements contained herein and understand that misrepresentations or omissions of facts called for is cause for rejection or expulsion

A yearly subscription to RESPIRATORY CARE journal and *AARC Times* magazine includes an allocation of $11.50 from my dues for each of these publications

NOTE Contributions or gifts to the AARC are not tax deductible as charitable contributions for income tax purposes However, they may be tax deductible as ordinary and necessary business expenses subject to restrictions imposed as a result of association lobbying activities The AARC estimates that the nondeductible portion of your dues — the portion which is allocable to lobbying — is 26%.

Signature _____

Date _____

Membership Fees

Payment must accompany your application to the AARC. Fees are for 12 months. (NOTE: Renewal fees are $75.00 Active, Associate-Industrial or Associate-Physician, or Special status; $90.00 for Associate-Foreign status; and $45.00 for Student status).

☐ Active	$ 87.50
☐ Associate (Industrial or Physicion)	$ 87.50
☐ Associate (Foreign)	$102.50
☐ Special	$ 87.50
☐ Student	$ 45.00
TOTAL	$_____

Specialty Sections

Established to recognize the specialty areas of respiratory care, these sections publish a bi-monthly newsletter that focuses on issues of specific concern to that specialty. The sections also design the specialty programming at the national AARC meetings.

☐ Adult Acute Care Section	$15.00
☐ Education Section	$20.00
☐ Perinatal-Pediatric Section	$15.00
☐ Diagnostics Section	$15.00
☐ Continuing Care-Rehabilitation Section	$15.00
☐ Management Section	$20.00
☐ Transport Section	$15.00
☐ Home Care Section	$15.00
☐ Subacute Care Section	$15.00
TOTAL	$_____

GRAND TOTAL = Membership Fee plus optional sections $_____

- ☐ Total Amount Enclosed/Charged $_____
- ☐ Please charge my dues (see below)

To charge your dues, complete the following:

- ☐ MasterCard
- ☐ Visa

Card Number

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Card Expires _____/_____

Signature _____

Mail application and appropriate fees to:

American Association for Respiratory Care • 11030 Ables Lane • Dallas, TX 75229-4593 • (972) 243-2272 • Fax (972) 484-2720

Manuscript Preparation Guide

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Categories of Articles

Research Article: A report of an original investigation (a study). Must include: Title Page, Abstract, Key Words, Introduction, Methods, Results, Discussion, Conclusions, and References. May also include: Tables, Figures (if so, must include Figure Legends), Acknowledgments, and Appendixes.

Review: A comprehensive, critical review of the literature and state-of-the-art summary of a topic that has been the subject of at least 40 published research articles. Must include: Title Page, Outline, Abstract, Key Words, Introduction, Review of the Literature, Summary, and References. May also include: Tables, Figures (if so, must include Figure Legends), Acknowledgments, and Appendixes.

Overview: A critical review of a pertinent topic that has fewer than 40 published research articles. Same structure as Review Article.

Update: A report of subsequent developments in a topic that has been critically reviewed in RESPIRATORY CARE or elsewhere. Same structure as a Review Article.

Special Article: A pertinent paper not fitting one of the other categories. Consult with the Editor before writing or submitting such a paper.

Editorial: A paper addressing an issue in the practice or administration of respiratory care. It may present an opposing opinion, clarify a position, or bring a problem into focus.

Letter: A brief, signed communication responding to an item published in RESPIRATORY CARE or about other pertinent topics. Tables, Figures, and References may be included. The letter should be marked "For Publication."

Case Report: Report of an uncommon clinical case or a new or improved method of management or treatment. A case-managing physician must either be an author or furnish a letter approving the manuscript. Must include: Title Page, Abstract, Key Words, Introduction, Case Summary, Discussion, and References. May also include: Tables, Figures (if so, must include Figure Legends), and Acknowledgments.

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Test Your Radiologic Skill: A brief, instructive case report pertinent to respiratory care and involving imaging, including one or more radiographs or other images submitted as black and white glossy photographs that clearly illustrate the teaching points being made. Must include: Questions, Answers, and Discussion.

Preparing the Manuscript

Double-space the text and number the pages. Do *not* include author names, author institutional affiliations, or allusions to institutional affiliations anywhere except on the title page. On the Abstract page include the title but do not include author names. Begin each of the following on a new page: Title Page, Abstract, Text, Acknowledgments, References, each Table, each Figure, and each Appendix. Use standard English in the first person and active voice. Type all headings in initial-capital letters (eg, Introduction, Methods, Patients, Equipment, Statistical Analysis, Results, Discussion). Center the main section headings and place second-level headings on the left margin.

Abstract. Please ensure that the abstract does not contain any facts or conclusions that do not also appear in the body text. Limit the abstract to no more than 250 words.

Key Words. Include a list of 6 to 10 key words or key phrases in Research Articles, Reviews, Overviews, Special Articles, and Case Reports. Key words are best selected from the Medical Subject Headings (MeSH) used by MEDLINE and available at *http://www.nlm.nih/gov/mesh/Mbrowser.html*.

References. Assign reference numbers in the order that articles are cited in your manuscript. At the end of the manuscript, list the cited works in numerical order. Abbreviate journal names as in *Index Medicus*. List all authors. If the research has not yet been accepted for publication, cite the research as a personal communication (eg, Smith KR, personal communication, 2001); *however, you must obtain written permission from the author to cite his or her unpublished data.* Do not number such references; instead, make parenthetical reference in the body text of your manuscript. Example: "Recently, Jones et al found this treatment effective in 45 of 83 patients (Jones HI, personal communication, 2000)."

The following examples show RESPIRATORY CARE's style for references.

Paper accepted but not yet published:

Hess D. New therapies for asthma. Respir Care (year, in press).

Article in a journal carrying pagination throughout the volume:

Legere BM, Kavuru MS. Pulmonary function in obesity. Respir Care 2000;45(8):967-968.

Article in a publication that numbers each issue beginning with Page 1:

Kallstrom TJ. Focus on asthma—disease management: a role for the respiratory therapist. AARC Times 1999;23(Oct):16, 17, 19.

Corporate author journal article:

American Association for Respiratory Care. Clinical Practice Guideline. Removal of the endotracheal tube. Respir Care 1999;44(1):85-90.

Article in journal supplement: (Journals differ in numbering and identifying supplements. Supply information sufficient to allow retrieval.)

Barnes PJ. Endogenous inhibitory mechanisms in asthma. Am J Respir Crit Care Med 2000; 161(3 Pt 2):S176-S181.

Abstract in journal: (Abstracts citations are to be avoided, and those more than 3 years old should not be cited.)

Volsko TA, De Fiore J, Chatburn RL. Acapella vs flutter: performance comparison (abstract). Respir Care 2000;45(8):991.

Editorial in a journal:

Giordano SP. What's that sound? (editorial) Respir Care 2000;45(10):1167-1168.

Editorial with no author given:

The perils of paediatric research (editorial). Lancet 1999;353(9154):685.

Letter in journal:

Piper SD. Testing conditions for nebulizers (letter). Respir Care 2000;45(8):971.

Book: (For any book, specific pages should be cited whenever reference is made to specific statements or other content.)

Cairo JM, Pilbeam SP. Mosby's respiratory care equipment, 6th ed. St Louis: Mosby; 1999:76-85.

Corporate author book:

American Medical Association Department of Drugs. AMA drug evaluations, 3rd ed. Littleton CO: Publishing Sciences Group; 1977.

Chapter in book with editor(s):

Isono S. Upper airway muscle function during sleep. In: Loughlin GM, Carroll JL, Marcus CL, editors. Sleep and breathing in children: a developmental approach. (Lung Biology in Health and Disease, Vol 147, Claude Lenfant, Executive Editor.) New York/Basel: Marcel Dekker; 2000:261-291.

World Wide Web

American Lung Association. Trends in pneumonia, influenza, and acute respiratory conditions mortality and morbidity. February, 2000. http://www.lungusa.org/data. Accessed November 20, 2000.

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New Products & Services

Ventilator. Pulmonetic Systems introduces a new addition to its LTV Series ventilators—the LTV800. According to the manufacturer, the LTV800 is designed specifically for the patient who requires volume ventilation, incorporating what they need and eliminating what they don't need. Pulmonetic Systems says that the LTV800 provides innovative technology and the essentials of a quality ventilator at an affordable price. For more information from Pulmonetic Systems, circle number 178 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

Digital Amplifier. SensorMedics has introduced its new Cephalo digital amplifier, for use in both sleep and EEG laboratories. The Cephalo amplifier recently received FDA approval, according to SensorMedics. According to their press release, the newly designed amplifier features built-in SAO_2, 23 reference channels, 9 separate differential channels, and 8 DC channels. The SAO_2 has been combined with the amplifier, says SensorMedics, reducing the space and cables needed in the lab. Data from and control information to the amplifier is transferred via a USB port. The maximum data collection rate is 1000 Hz. For more information from SensorMedics, circle number 179 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

Medical Device Manufacturers & Suppliers Database. ECRI has announced the availability of the newly enhanced Health Devices International Sourcebase, which they describe as an international Web-based database of medical device manufacturers and suppliers and their products, and the 2002 print edition of the *Health Devices Sourcebook*, which should be available in November 2001. The Sourcebase database contains information on more than 13,000 worldwide confirmed manufacturers and distributors of medical equipment—from disposables & sharps to nurse call systems and imaging equipment. According to ECRI, the information is updated continually, and changes are posted monthly to the Web site. For more information from ECRI, circle number 180 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

Patient Simulator. Armstrong Medical offers *Rhythm*SIM™ basic and advanced patient simulators for practice in ACLS and PALS training where students learn cardiac rhythms in real time. According to Armstrong, *Rhythm*SIM offers more than 60 simulated rhythms, and upgrade modules are also available. The manufacturer says that *Rhythm*SIM can use a standard ECG monitor and simulates between one and 12 leads while operating on both AC and DC power. It is fully portable, with up to 20 hours of battery power, and also features a low-battery indicator, according to Armstrong. Armstrong also says that *Rhythm*SIM can be used in conjunction with many defib manikins and creates a new "patient" scenario during students' responses. There is also an optional TV interface available, designed for teaching large groups. For more information from ECRI, circle number 181 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

Incentive Spirometer. DHD Healthcare Corporation announces development of an innovative low-flow incentive spirometer that they say helps prevent lung infections following surgery. This new device, called CliniFLO, has 6 settings ranging from 100 mL/sec to 600 mL/sec, and accommodates virtually any patient's flow requirements, according to DHD Healthcare. Special features that the manufacturer says are on the CliniFLO include a user-friendly indicator that simplifies training and helps patients maintain the correct inspiratory flow rate, and a flow rate dial on the *back* of the unit, which DHD claims will reduce the chances of patients adjusting their own settings. For more information from DHD Healthcare, circle number 182 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

Not-for-profit organizations are offered a free advertisement of up to eight lines to appear, on a space-available basis, in Calendar of Events in RESPIRATORY CARE. Ads for other meetings are priced at $5.50 per line and require an insertion order. Deadline is the 20th of the month two months preceding the month in which you wish the ad to run. Submit copy and insertion orders to Calendar of Events, RESPIRATORY CARE, 11030 Ables Lane, Dallas TX 75229-4593.

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Oct. 16	Professor's Rounds 2001 Teleconference, Program 7	AARC, (972) 243-2272
Oct. 23	Professor's Rounds 2001 Live Videoconference, Program 8	AARC, (972) 243-2272
Oct. 25–26	New Jersey Society for Respiratory Care's 2001 Shore Conference; **Atlantic City, NJ**	Maura McGovern at (973) 537-3919 or mmcgovern@saintclares.org; www.njsrc.org
Nov. 20	Professor's Rounds 2001 Teleconference, Program 8	AARC, (972) 243-2272
Dec. 1–4	47th International Respiratory Congress; **San Antonio, TX**	AARC, (972) 243-2272, www.aarc.org
Feb. 6–8, 2002	West Virginia Society for Respiratory Care's Winter Meeting; **Davis, WV**	Jay Wildt at (304) 442-7474 or jay.wildt@mghwv.org; or Anna Parkman at (304) 357-4837 or AParkman@ucwv.edu.

Date	Other Meetings	Contact
Oct. 9–11	Cardiorespiratory Diagnostics 2001; **Las Vegas, NV**	Medical Graphics Corporation, Mari Orke, (800) 950-5597, ext. 444, www.medgraph.com
Oct. 12	3rd Annual Rainbow Babies & Children's Pediatric/Neonatal Respiratory Conference; **Independence, OH**	Nancy Johnson at (216) 844-1954
Nov. 1–2	13th Annual Conference on High-Frequency Ventilation and Other Advances in Perinatal/ Neonatal Care; **Tempe, AZ**	St. Joseph's Hospital and Medical Center, Cathy Martinez, (602) 406-3512, fax (602) 406-4123
March 20–23, 2002	21st Annual Big Sky Pulmonary & Critical Care Medicine Conference; **Big Sky, MT**	American Lung Association of the Northern Rockies, (406) 442-6556, ala-nr@ala-nr.org

Notices

Notices of competitions, scholarships, fellowships, examination dates, new educational programs, and the like will be listed here free of charge. Items for the Notices section must reach the Journal 60 days before the desired month of publication (January 1 for the March issue, February 1 for the April issue, etc.). Include all pertinent information and mail notices to RESPIRATORY CARE Notices Dept, 11030 Ables Lane, Dallas TX 75229-4593.

Scheduled Professor's Rounds 2001

Program #7 Invasive Ventilation: The Latest Word—Richard H Kallet MS RRT; Host Richard D Branson BA RRT FAARC—Video September 25 Audio October 16

Program #8 Test Your Lungs-Know Your Numbers-Prevent Emphysema—Thomas L Petty MD FAARC; Host David J Pierson MD FAARC—Video October 23 Audio November 20

Helpful Web Sites

American Association for Respiratory Care
http://www.aarc.org
— Current job listings
— American Respiratory Care Foundation fellowships, grants, & awards
— Clinical Practice Guidelines

National Board for Respiratory Care
http://www.nbrc.org

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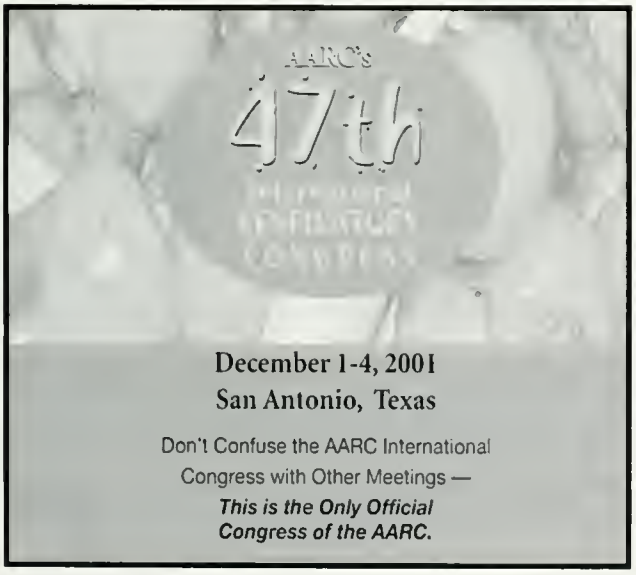

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For information about other services or fees, write to the National Board for Respiratory Care, 8310 Nieman Road, Leneva KS 66214, or call (913) 599-4200, FAX (913) 541-0156, or e-mail: nbrc-info@nbrc.org

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